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SPACE SCIENCE ADVISORY COMMITTEE

November 17–18, 2003

NASA Ames Research Center
Moffett Field, CA

MEETING REPORT

Marc S. Allen	**Andrew B. Christensen**
Executive Secretary	**Chair**

SPACE SCIENCE ADVISORY COMMITTEE (SScAC)
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Welcome and Opening Remarks
Dr. Andrew Christensen, chair of the Space Science Advisory Committee (SScAC), welcomed the members and visitors and noted changes in the agenda, including a contraction in the meeting duration to 2 days only (Monday and Tuesday).

Mr. G. Scott Hubbard, Director of the Ames Research Center (ARC), welcomed the Committee and visitors. He described the programs at ARC, which has moved beyond its roots in aeronautics to space science fields such as the Stratospheric Observatory for Infrared Astronomy (SOFIA), the Kepler mission, oversight of the NASA Astrobiology Institute (NAI), and mission software for the Mars Exploration Rovers mission (MER). ARC's background in high-performance computing grew out of its work in computational fluid dynamics and has expanded to include software development and information technology in support of NASA space missions. Application areas include science mission planning, human factors preparation for scientists working on missions, and autonomous systems for missions such as the Mars Science Laboratory (MSL). Past successes in high-end computing at ARC are continuing to drive applications in graphical displays, climate modeling, and data visualization. Potential applications to space science from the nanoscience and nanotechnology group at ARC include sensor systems, self-assembly, and micro-miniature high-capacity memory and data processing arrays. Mr. Hubbard described ARC issues of sustaining facilities such as the large wind tunnel that was used to test the MER parachute in the face of NASA's change to full-cost accounting. He also described ARC's partnerships with a new university-affiliated research center and the private sector companies and academic institutions involved in the NASA Ames Research Park.

Dr. Christensen introduced the two new SScAC members, Dr. Jonathan Grindlay and Dr. Michelle Thomsen. Dr. Marc Allen, the SScAC Designated Federal Official, reviewed logistics details for the meeting.

Ethics Briefing
Ms. Comon Sebuani and Mr. Kevin Kouba of the ARC General Counsel's Office presented Mr. Andrew Falcon's briefing on rules applicable to Special Government Employees serving on NASA advisory committees. They reviewed the fundamental ethics principles behind the regulations: public service is a public trust, employees may not have financial interests that conflict with their actions on behalf of the Government, and they may not use nonpublic information improperly. Members should avoid even the appearance of an impropriety. Special Government Employees are subject to civil service ethics rules and post-employment restrictions. The presenters reviewed the criminal code rules under 18 USC 203 and 205, which cover prohibitions on representational activities before the Federal Government and involvement in matters in which there is a financial interest. They described the post-employment restrictions on representation and the rules and exceptions on receipt of gifts as a Special Government Employee. The briefing closed with points of contact for ethics advice, and the presenters emphasized the importance of seeking advice in advance of a situation that might involve a violation.

Associate Administrator's Introduction

Dr. Edward Weiler, NASA Associate Administrator for Space Science, provided an update on the Space Science Enterprise. The Space Infrared Telescope Facility (SIRTF) was successfully launched on August 25. Dr. Weiler commented on the four launches this summer using Delta rockets. Preliminary data from SIRTF include an image of "first light" after the Big Bang. Details are scheduled to be released at a press conference on December 18, 2003, when the SIRTF will receive its observatory name. The Chandra X-ray Observatory has detected "sound waves" from a black hole. Dr. Weiler noted the scientifically significant results obtained from Galileo during its last hour before impacting on Jupiter. The Mars Orbiter Camera on the Mars Global Surveyor (MGS) has provided images of a delta on Mars. A coronal mass ejection in October was the largest solar flare ever observed. To avoid damage from the resulting radiation, 16 spacecraft including the two MER spacecraft were put into safe mode. All missions are now back in operation.

Dr. Weiler summarized the status of missions coming up in fiscal year (FY) 2004, including Gravity Probe–B, the Swift gamma-ray burst Explorer, the Mercury Surface, Space Environment, Geochemistry and Ranging mission (MESSENGER), and Deep Impact. The MER named Spirit is scheduled to land on January 3, 2004, with confirmation of a successful landing expected on January 4. The Opportunity MER will land on January 25. The Japanese Nozomi spacecraft is thought to be severely impaired and is currently on a trajectory for a Mars orbit with a low point at 900 km above the surface. There is a small probability that the spacecraft, if inoperable, could impact the martian surface. Orbit insertion for Mars Express will be in December 2003, with the Beagle-2 lander reaching the surface on December 26. Cassini/Huygens will enter its orbit around Saturn in July 2004. Stardust will encounter comet Wild 2 in January 2004 and return to Earth with samples in January 2006. The Genesis mission will return to Earth with samples in September 2004.

Dr. Weiler reviewed the budget history for the Office of Space Science (OSS). All of NASA is still operating on a congressional Continuing Resolution, with an FY 2004 budget not expected until January or February. This means that FY 2004 program starts or budget increases are delayed. Dr. Weiler next discussed the impact on OSS programs of the final report from the *Columbia* Accident Investigation Board (CAIB), which emphasized that NASA should treat the Shuttle as a developmental vehicle. The only OSS impact is on servicing missions to the Hubble Space Telescope (HST). In his review of background facts and prior decisions related to HST, Dr. Weiler stressed that Servicing Mission 4 (SM-4) that was in the November 2002 baseline plan for HST is unbudgeted and unfunded. Any servicing mission using the Shuttle now must include the cost of the Shuttle trip. To service the HST, the Shuttle must fly to an orbit with no safe haven, and the CAIB recommended that such flights not be undertaken without the ability to repair a wing leading edge before returning to Earth. Although NASA is working on the required repair capability, it does not yet exist. The earliest date now for Shuttle Return to Flight (RTF) is September 2004, and the earliest date for an HST servicing mission appears to be March 2006. Keeping the SM-4 team in place until then will cost $180 million, half of which will come from the Astronomy and Physics Division (APD), the other half from other OSS budget themes. In response to suggestions from the space science community that Congress would be willing to provide the additional support for SM-4 and even a fifth servicing mission (SM-5), Dr. Weiler reviewed the history of budget increases for HST and the congressional response. Although Congress has allowed or mandated increases of $4 billion for HST (from a baseline of $3 billion to $7 billion in actual costs), only $100 million of additional funding was appropriated. The remainder came out of existing OSS budget lines.

In this context, Dr. Weiler discussed the task given to the HST–James Webb Space Telescope (JWST) Transition Plan Panel (also called the "Bahcall Panel" for its chairman, John Bahcall) and the three scenarios for which the panel provided recommendations. He discussed the issues and controversies that have arisen in response to the Bahcall Panel's preferred option of completing SM-4 in 2005 and adding an SM-5 in 2010, if SM-5 is successful in a peer-reviewed competition with other new space astrophysics proposals. Dr. Weiler does not favor an option that disrupts the Explorer or Discovery programs. He suggested that, given the technical uncertainties in Shuttle RTF and flights to an HST servicing orbit, as well as plans in progress to demonstrate robotic rendezvous using an expendable launch vehicle (ELV), there was no need to make a decision on SM-5 at this time. Dr. Weiler answered members' questions on details of SM-4 and factors that could affect servicing missions for HST. He then summarized the status of actions in response to the SScAC recommendations from the August 2003 meeting and answered questions about the MESSENGER reprogramming and lessons learned for Explorer and Discovery-class missions. Dr. Christensen added that SScAC may be returning in the future to issues concerning the Discovery program.

Bahcall Panel Report Summary

Dr. Christopher McKee, a member of the Bahcall Panel, discussed the panel's final report and a subsequent letter from the panel to Dr. Christensen as chair of SScAC. (The full text of the letter is in Appendix I.) The context in which the panel worked was that the entire situation for HST end-of-mission planning had changed with the *Columbia* catastrophe. The panel was impressed by the work being done to prepare for JWST.

Dr. McKee reviewed the panel's recommendations related to three scenarios for shuttle servicing missions. For the scenario in which only one more servicing mission was possible, the panel stressed that any delay in the scheduling of the mission be used to improve the technology of the replacement gyros that would be installed by that mission. The panel studied two options for deorbiting the HST by installing a propulsion module either during a shuttle servicing mission or through a robotic installation using an uncrewed, ELV-launched rendezvous flight to HST. For the scenario with two Shuttle servicing missions, the panel recommended that the second mission (SM-5) be undertaken only if its science potential won in a peer-reviewed competition against alternatives for similar space science. For example, SM-5 would compete with other planetary missions if the new science potential for HST were primarily planetary. Dr. McKee explained the reasoning of the panel, related to stimulating the best ideas for new science to be done with the HST, that underlay the suggestion for a competition. The panel was also influenced by the reasoning and earlier recommendations of the committee chaired by David Black, with which it substantially agreed.

Dr. McKee agreed with Dr. Weiler's point that cost estimates developed after the Bahcall Panel reported have major implications for the viability of competing SM-5 with other new missions. When the panel met, only rough estimates were available for the additional costs associated with a science component to SM-5. Dr. McKee remarked that the new estimates for deorbiting HST assumed an ELV robotic mission, for which the costs are so high that it renders competition with Explorer and Discovery missions infeasible. He said the panel had never conceived of the competition as requiring radical change to the Discovery program. The panel thought that the possibility of using SM-5 to attach a propulsion module to HST should be explored as a way to minimize the total cost of an extended HST mission. In this context, he said the letter from the panel to Dr. Christensen was meant to clarify two points. First, the panel did not intend that the SM-5 should delay any of the astronomy decadal survey missions. Second, the reference to competing SM-5 with Explorer and Discovery missions had been meant as just an example, but

those examples were now irrelevant because the high SM-5 cost far exceeds that of any single Discovery or Explorer mission.

Dr. McKee answered questions from SScAC members on the new instruments that had been suggested for delivery to the HST with an SM-5, and the time required to develop such instruments. In response to another question, he iterated the point that the panel had not discussed competing an SM-5 against multiple missions from other programs. Dr. Weiler noted issues and obstacles confronting any plan to use the Shuttle to attach a propulsion module to the HST. He also noted that NASA staff had never presented the suggestion of a peer-reviewed competition for SM-5 as involving competition with the priority flagship missions presented in the decadal survey. In response to a question from Dr. Fiona Harrison, Dr. McKee said that the Einstein Probes might be a reasonable mission to be competed with an SM-5 because part of an HST extension could do some of the science being considered for the proposed Supernova/Acceleration Probe (SNAP).

Two-Gyroscope Steering Mode for the HST

Dr. Steven Beckwith of the AURA/Space Telescope Science Institute described the work to develop a two-gyroscope steering mode for the HST that would allow useful science investigations to continue. In principle, the HST can be pointed with just two gyros. He estimates that a workable two-gyro steering mode would extend the usable life of HST by about 15 months beyond the loss of the third working gyro. Without an SM-4 to replace gyros, the estimated date at which there would be less than three working gyros is the end of 2005, assuming the past rate of gyro failure continues. The last servicing mission to replace gyros was in 1999; since then, two gyros have failed. If SM-4 is delayed beyond 2005, then battery failure also becomes likely. Dr. Beckwith showed a graph of the projected lifetime of a minimum complement of three gyros under varying servicing mission scenarios. If SM-4 occurs by 2005, three-gyro availability extends until about 2010. An SM-5 around that time would add about five more years to projected three-gyro availability.

The technical details of how to implement a two-gyro mode are one part of the issue. The other part is how the science capability would be affected by degradation to a two-gyro mode. The pointing jitter will increase, and Dr. Beckwith showed simulations of the impact of the estimated jitter in two-gyro mode on the ability to acquire guide stars. The impact is greatest at short wavelength and high resolution, so two-gyro steering will affect small slit, high-resolution observations significantly, with little effect on widefield mode. Dr. Beckwith illustrated the impact with hypothetical consequences for the Cycle 12 science program for HST. In Cycle 12, the widefield Advanced Camera for Surveys (ACS) was installed, and the trend in HST science has been toward widefield surveys aimed at evaluation of objects with redshifts of 5 to 6 and high-redshift supernovae. The surveys planned for the next one to three years could be accommodated in two-gyro mode. Dr. Beckwith discussed with SScAC members the possibility that observations beyond three years would trend back from surveys to observing specific distant-universe objects. He said the capability to do that would be compromised if only two-gyro steering were available. In response to a question about moving more high-resolution work to the near term, before gyro failures occurred, Dr. Beckwith said that the current plan maximizes the science return, as the most compelling questions are being addressed by the current or planned widefield surveys. Other questions asked were about the basis for the estimate of gyro life (mean time before failure) and the expected lifetime for three-gyro steering if SM-4 replaces all gyros in 2006. Dr. Beckwith described the challenges remaining to be met before NASA has an initial operating capability for two-gyro mode and the basis for estimating the life expectancy of the current nickel–metal hydride batteries. He emphasized the importance of having SM-4 no later than 2006 to avoid a possible shutdown to safe mode triggered by low battery power.

During lunch, Dr. Robert Lin of the University of California, Berkeley, gave an informal presentation to SScAC on results from the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) mission.

Astronomy and Physics Division (APD) HST Issue Presentation

Dr. Anne Kinney, APD Director, began with a summary of the status of APD operational and developmental missions. All missions launched this year are up and operating. The August launch of SIRTF means that all three great observatories are operating. APD missions, including Chandra, HST, and the Rossi X-ray Timing Explorer (RXTE), provided 11 NASA Space Science Updates during the past year.

Among missions in development, the Space Interferometry Mission (SIM) and JWST successfully passed initial confirmation reviews to enter Phase B. Both missions required replans to meet cost constraints. Gravity Probe–B (GP-B) has been delivered to Vandenberg Air Force Base in preparation for launch. However, GP-B does not yet meet all launch criteria, and the schedule impact is not yet certain. For JWST, the beryllium-based primary mirror technology was selected. The programs for the Beyond Einstein strategic missions—the Laser Interferometer Space Antenna (LISA) and Constellation X—are about to begin. The major budget problems for the division continue to be GP-B and the cost of funding the delay in SM-4. The delay in launch schedule for the Swift gamma ray burst Explorer is a third key issue.

Dr. Kinney then gave a presentation specifically on end-of-mission planning for HST. She reviewed the rationales for and tasks given to each of the three HST review panels that reported in the past year and the NASA assessment of the panel reports and recommendations. The NASA Administrator has now required that an autonomous rendezvous and capture capability be developed for deorbiting the HST. Dr. Kinney reviewed the principles that would be applied to a competition of SM-5 with other proposed missions or programs. The cost cap for the Announcement of Opportunity (AO) would be based on the estimated cost of a full SM-5 mission, including manpower, spacecraft, instruments, operations, and data analysis and archiving for the full term of the mission. The cost cap would also include reserves for the risk that SM-5 might be delayed or that scientific instruments were not ready to launch. The competition would be conducted with a traditional AO to solicit science investigation proposals; a science peer review; and a technical, management, cost, and other (TMCO) review. The science elements included in the competition would be Explorer, Discovery, and Beyond Einstein missions. The challenge for NASA in conducting such a competition is that the Discovery and Explorer programs are the only funded lines for new science missions that are not decadal survey missions. Dr. Kinney also presented the recommendation from the Astronomical Search for Origins Subcommittee (OS) for mission concept studies, to be solicited through a NASA Research Announcement (NRA), for science investigations addressing science goals of the Origins theme and requiring a strategic-class (not Explorer class) mission. The scope of this NRA would include SM-5, Origins Probes concepts, and possibly other astrophysics missions. The missions under study would be targeted for some time after an Origins strategic initiative was accepted for the FY 2006 time frame. Dr. Kinney noted that this approach would require priority setting by the Origins science community, similar to what the Structure and Evolution of the Universe community did in preparing its Beyond Einstein roadmap. Dr. Kinney answered questions from SScAC about the principles of competition and the Origins NRA alternative as proposed by the OS. Dr. Weiler addressed questions on the timeline for continuing to carry the SM-4 preparation effort if there are further delays in the earliest time for a Shuttle mission to the HST.

Subcommittee Recommendations on HST

The four chairs of SScAC subcommittees each reported on the subcommittees' deliberations and recommendations concerning the HST servicing and end-of-mission planning alternatives. Dr. David Spergel reported for the Search for Astronomical Origins Subcommittee (OS), Dr. David McComas for the Sun–Earth Connection Advisory Subcommittee (SECAS), Dr. Edward Kolb for the Structure and Evolution of the Universe Subcommittee (SEUS), and Dr. Jonathan Lunine for the Solar System Exploration Subcommittee (SSES). The full text of each subcommittee's letter to Dr. Christensen is in Appendices E through H. The responses to the SM-5 competition recommended by the Bahcall Panel report were the major focus of the presentations and ensuing discussions.

The OS endorsed proceeding with SM-4 as quickly as possible. It also endorsed the National Academy of Sciences' astronomy decadal survey priorities for the Origins theme: JWST, SIM, and the Terrestrial Planet Finder (TPF). The OS recommended that Explorer and Discovery missions should not be competed against SM-5. Rather, the OS suggested that SM-5 should compete through the OSS strategic planning process for selecting the most scientifically compelling missions, where SM-5 could compete with other concepts for the next major initiative in the Origins theme. Another option suggested by the OS would be to compete SM-5 against one of the Einstein Probe missions, such as the Joint Dark Energy Mission (JDEM).

The SECAS response on the HST scenarios dealt exclusively with the impact on the Explorer program. After a careful review, the SECAS affirmed the essential importance of the Explorers to Sun–Earth Connection (SEC) disciplines and found that any disruption of the Explorer program resources would have a drastic negative impact on the SEC program. The SECAS letter also listed major scientific achievements of the SEC-oriented Explorers. The three mission operations working groups within the SEC community also advised against involving the Explorer program in a competition with SM-5.

The SEUS acknowledged the unique and historic contributions of the HST and described the work on a two-gyroscope steering mode as impressive. However, this subcommittee unanimously opposed competing SM-5 with the Explorer or Discovery missions and suggested that OSS pursue the one-servicing mission scenario, with SM-4 completed as early as feasible and deorbiting of HST when forefront science can no longer be conducted. Any idea for post-SM-4 servicing of HST should go through the OSS strategic planning process. The SEUS also had concerns about the work to develop a robotic "claw" technology for deorbiting the HST. Dr. Kolb noted that JDEM is a joint effort with the Department of Energy (DOE), and it seems unlikely that the DOE would agree to commit its dark energy resources to a competition with SM-5.

Dr. Lunine, presenting the SSES recommendations, acknowledged the contributions of the HST to planetary science. With respect to the Bahcall Panel report, the SSES focused on the impact of the proposed SM-5 competition on the Discovery program. The SSES letter to Dr. Christensen noted the importance of the Discovery program to the community (as exemplified in the solar system exploration decadal survey), the high cost of an SM-5 relative to individual Discovery flights, and the impact of losing multiple Discovery missions to fund the SM-5. From these points, the SSES concluded that the cost to the Solar System Exploration Division's mission diversity and science return would far outweigh any possible benefit from a fifth servicing mission to extend HST if SM-5 were funded with Discovery resources.

The SScAC discussion of the subcommittee reports included options for funding an SM-5 mission other than competing against Explorer or Discovery missions, the likelihood of having

instruments ready in time for an SM-5 mission if the OS suggestion were adopted, schedule risks for JWST, and strategic priorities in light of possible funding reductions across all OSS programs. Dr. Allen said that no members of the public had requested time to comment on the HST issues. Therefore, the agenda time for public comment was used to continue the committee's discussion of HST end-of-mission alternatives.

The consensus was that a competition of SM-5 against Discovery or Explorer missions was not desirable. Several members expressed support for the OS suggestion of an Origins Probes competition with SM-5. Other members emphasized that an SM-5 concept should move through the strategic planning process already in place and used for NASA flagship missions and the Explorer and Discovery programs. Members requested that SScAC make a statement of support for the Explorer and Discovery programs. The members agreed that completing SM-4 as quickly as possible was a priority for OSS. Various ways of responding constructively to the Bahcall Panel's recommendations were discussed. Dr. Christensen closed the discussion session, saying that the subcommittee chairs would work on draft language for recommendations to Dr. Weiler, with the draft recommendations to be considered by the entire committee on Tuesday.

Status of the Suborbital Rocket Program

Dr. Richard Fisher, Director of the Sun–Earth Connection Division, described current and planned operations of the suborbital rocket program. The White Sands Missile Range launch manifest for suborbital rockets in FY 2004 includes a mix of solar and geophysical payloads. Ten launches are budgeted for FY 2004. Nine payloads are on the current manifest, and five additional payload slots have been requested by investigators. The Kwajalein campaign has included 14 flights for four experiments. Dr. Fisher described the plans for extending flight durations through use of a tailored trajectory. This approach, which was demonstrated in the University of Alaska's HEX mission to measure vertical winds, opens up a new regime for suborbital flight operations.

At the end of FY 2005, the inventory of launch vehicles will be down to 13 motors, which the program believes is insufficient to ensure continuity of supply. The program has requested an overguide budget increase to procure an additional three rockets in FY 2004 and 2005, which would provide adequate inventory until the next major procurement begins in FY 2006 (12 to 14 rockets per year). Dr. Fisher described the rocket motor procurement. Procurement of new high-altitude sounding rockets would allow heavy payloads to be carried through a substantial fraction of a single Earth orbit. These rockets will also need larger fairings to accommodate larger and heavier instruments. Four options for the new rockets are under consideration, and Dr. Fisher highlighted the technical differences and issues associated with each option. The high-altitude rockets will be more expensive—up to $5 million each—and the launch schedule will be driven by availability of funds.

The suborbital rocket flight program costs about $30 million a year, a third of which is for developing science payloads and is distributed across the Space Science Enterprise science disciplines. Dr. Fisher reviewed the time lines for the new vehicle technology and system technology. In concluding, Dr. Fisher said that the suborbital rocket program is viewed as invaluable in terms of technology development (first operational flights of new technology before it is considered proven for use in major space flights) and education. He is less certain about the value of the science being done and intends to examine that aspect in greater detail during the next year. His results will be presented to SECAS and SScAC for comment. In answer to a question from Dr. Lunine, he said the older type of rocket will still be available in the inventory, but the mix of those and the more capable high-altitude rockets is not yet determined.

Tuesday, November 18, 2003

Dr. Christensen reconvened the meeting at 8:00 a.m. and reviewed the agenda for the day.

Dr. Weiler requested time to address SScAC and make some corrections and clarifications to his comments during the previous day's discussions of the Bahcall Panel report. He said he had misread one paragraph of the letter from the Bahcall Panel to SScAC as representing the position, expressed informally in emails and other comments from portions of the science community, that portions of the astronomy decadal survey mission programs might be cut to accommodate an SM-5 mission to the HST. He recognized that the Bahcall Panel letter and final report had not recommended this, and he repeated his prior statements that the panel had provided thoughtful options appropriate to the context in which the panel had worked. He said that he had heard strong support for SM-4 during the Monday discussions and, if that were the consensus of the committee, then it would be important to state that in its written report to him. The issue of competing SM-5 against Discovery or Explorer missions has, he said, been bypassed by the post-Columbia slip of a possible SM-4 to not earlier than FY 2006. If SScAC were to agree with the alternative suggested by the OS, he would not read a recommendation for that alternative as requesting special consideration for the projects to come forward through an Origins NRA. Rather, it would simply acknowledge that the OS alternative represents a reasonable response to the Bahcall Panel's recommendation. Given the uncertainties in Shuttle Return to Flight, the availability of the Shuttle to fly to the HST orbit, and other relevant factors, he thought a compromise like that suggested by the OS may be the best that could be done at this time.

Dr. Christensen said that Dr. Weiler's comments had touched on some of the emerging areas of concern, and SScAC would heed them during its deliberations.

NASA Advisory Council Issues

Dr. Christensen led the committee in addressing the following set of questions from the NASA Advisory Council (NAC) regarding the draft NASA strategic plan.

Question 1: Does the discipline strategy represent the present reality for the Enterprise, and does it delineate the next steps to be taken?

After discussion about the draft of the strategy to which the question refers and the contexts where a strategy for astrobiology is described, the consensus was that the amount of description for any of the Space Science Enterprise themes and related disciplines was at a very high, general level. To explain why NASA Goal 4 does not reference the Space Science Enterprise, Dr. Allen described how the goals in the strategy were framed to represent particular NASA enterprises. Goal 4 was framed to represent science performed by Code U on the International Space Station (ISS).

Question 2: How strong is the connectivity (between the NASA Enterprises) to the NASA Strategic Plan? Does it adequately represent the needs and issues of the Enterprise?

Several members commented on how briefly some of the science discipline areas were mentioned in the body of the Agency strategic plan. There was further discussion of whether Goal 4 should cover space science efforts, as well as ISS science, because Goal 5 omits the point that Space Science Enterprise themes are doing fundamental physics and pushing the frontiers of physics forward.

Question 3: With respect to the broad, overarching issues: In human capital, identify the needs of the Enterprise in terms of training. What is the skill mix that the Enterprise would need, and does

it have it? Does the Enterprise work effectively with the Education Enterprise? Does the Education Plan adequately reflect the knowledge that the Enterprise needs?
With respect to the last part of Question 3, Dr. Christensen noted that the education plan barely mentions space science. The members discussed the lack of attention in the strategic plan draft to OSS education and public outreach (E/PO) and other education and training efforts within the Space Science Enterprise. They contrasted this with the emphasis in the Space Science Enterprise Strategy on education and outreach and the strength of OSS E/PO. The members did feel that OSS E/PO activities are well aligned with the NASA E/PO objectives and the overall education goal. Ways in which Code N and Code S E/PO programs could interact more effectively were discussed. Martin Kress described a number of OSS educational initiatives. SScAC also discussed approaches to increasing the enrollment of students in scientific and engineering studies that will be needed to support space science missions in the future and to expanding the network of informal educational settings (museums, nonclassroom learning venues) reached by NASA educational activities.

Question 4: Comment on the following issues: What does NASA's posture communicate to the public and the constituencies important to the Committee? What is the connection to the Communication Enterprise?
The members discussed the importance of the Space Science Updates on results of OSS missions in communicating a sense of the scientific value of the Enterprise to the public. There are indirect processes through which the broader media pick up and communicate information from announcements and Space Science Updates. The use of NASA-developed materials in textbooks for elementary and middle school level education was noted as a desirable result of E/PO efforts. Another topic was whether NASA as a whole, and space science in particular, was sustaining its image of success and adventure in space exploration, in the face of changing national priorities and concerns. Dr. Christensen wrapped up the discussion by summarizing the reasons why the NAC had asked the questions about the draft strategic plan. He said he would use the members' comments as the basis for his report back to the NAC at its next meeting.

Honoraria for Peer Review Panel Members
Dr. David Bohlin of the OSS Headquarters staff asked SScAC to consider whether NASA should, as a general policy, offer honoraria to scientists who participate in its peer review panels. OSS currently offers honoraria for most of its AO review panels and some other panels, but for only a few of the NRA grants panels. Mr. Bohlin reviewed the rates typically paid now for panel members and chairs on review panels for which honoraria are offered. In FY 2003, the total costs for the NASA Peer Review Services contractor for OSS panels, covering travel, logistics, and contractor salaries, totaled about $4 million out of a total research and analysis (R&A) budget of $210 million (without full-cost accounting for NASA Centers). The estimated cost of providing honoraria for all review panels including NRAs would be $350,000 to $500,000 per year. Dr. Bohlin reviewed a list of reasons for and against offering honoraria that he had gathered from OSS staff. In response to a question on whether OSS staff assembling panels were experiencing difficulties in recruiting participants without offering an honorarium, he said that it can be arduous to assemble a panel. Dr. Fiona Harrison noted that the honorarium could make a difference in some expertise areas. Dr. McComas described the issue in terms of considering the trade-off between minimizing management and administrative costs of running peer reviewed programs and the potential to improve the quality or reduce other costs by offering honoraria. The members discussed the opportunity costs and benefits of participating in review panels and ways in which travel and similar obstacles to participation could be lowered, whether or not an honorarium were offered. The view that participation on review panels constituted a form of "national service" in some academic institutions was also discussed. Several members expressed concern that future R&A funding levels might be squeezed by overall NASA budget cuts, making

this an inopportune time to change the honorarium policy. Dr. Bohlin said that a uniform policy would be easier to administer than the current non-uniform practice. Overall, the discussion indicated split views, with some SScAC member seeing strengths on both sides of each of the thematic issues. After each member had expressed their thoughts on the question, Dr. Christensen called for a three-way vote on (1) making honoraria the general policy in OSS, (2) changing to a no-honorarium policy for all science review panels, or (3) keeping the current non-uniform practice. By a large majority, the SScAC members favored retaining the current case by case practice.

Update on MESSENGER and Cost Cap Issues

Mr. Orlando Figueroa, Director of the Solar System Exploration Division, began with additional status information on the Mars missions. The computers on board the two MER spacecraft, which are headed to their primary landing sites, were rebooted successfully after the spacecraft were placed in safe mode during the large coronal mass ejection in October. One instrument on Mars Odyssey may have been damaged by the solar particle storm.

Mr. Orlando next discussed systemic issues with the Discovery program and efforts to address them. The SScAC discussions about the MESSENGER mission would apply as well to Deep Impact and to DAWN as well. He reviewed the rationale for the program's cost cap, which enables new missions to be selected at the frequency recommended in the solar system decadal surveys, while protecting the data analysis program, commitments to missions in development, and commitments to operational missions. He also acknowledged the competitive pressures that push mission proposals to the cap. To address issues in maintaining the cap, process improvements are being implemented beginning with the Discovery AO and continuing through the Phase B confirmation. Key management and engineering principles must be followed. Interaction will be increased between the science review panels and the TMCO reviews. As part of the selection process, a performance floor will be set for each mission. The discipline exercised in the Scout program of halting an underperforming mission at the Phase A downselect or Phase B confirmation needs to be applied to Discovery missions. Workshops will be used to extract lessons from the problems that have arisen in the later phases of missions and apply them to the earlier phases of the project, when there is more chance of recovery. Although NASA already has a database for lessons learned, it lacks the context necessary to know when a lesson applies in different circumstances.

In the support infrastructure for Discovery missions after selection, there will be a single point of contact for the core functions associated with mission development and oversight. This infrastructure must be able to assess needs quickly and modulate the support structure required to ensure adequate oversight. It will also provide PIs with access to technical expertise, provide training for novice PIs, coordinate the capture of lessons learned, and assist in identifying the long-term technology and E/PO needs of the Discovery program and missions.

Mr. Figueroa reviewed the SScAC's recommendations on MESSENGER and NASA's actions in response. The spacecraft will be fully assembled within the next week. The full load of launch software is still being completed, and the thermal vacuum test in January means the schedule for a May launch is tight. He remains concerned about the rate at which schedule reserve is being used. Several checks on progress have been strengthened, including independent reviews and assessments. The budget reserves for both MESSENGER and Deep Impact are inadequate, and the tight schedules require special attention. The reserves for Genesis, Stardust, and Kepler appear adequate. Descopes of the Dawn mission have improved its reserves, and a confirmation review is scheduled for December. The Discovery program is still on schedule for release of the next AO in February 2005. However, further cost problems with MESSENGER or Deep Impact

could delay it. Results from the lessons learned workshop held in November will be available to potential proposers.

Dr. Christensen said that SScAC would wait to see how the program develops and what happens with the new National Research Council (NRC) Space Studies Board report described by Dr. Weiler. Dr. Richard Fisher noted that a useful set of lessons learned from a recent Explorer program workshop are available on that program's website. The Explorer program will also emphasize the use of the Phase A downselect and the Phase B confirmation as decision points for terminating poorly performing missions.

Subcommittee Recommendations on Non-HST Issues

Dr. Lunine summarized the discussions and recommendation to SScAC from the October meeting of the SSES (full report in Appendix H). The SSES commended the scientists and engineers of the Solar System Exploration Division for their work in correcting problems with the MESSENGER, Deep Impact, and Dawn missions. It described the Discovery program as scientifically vigorous and noted the efforts of the division to implement the SSES and SScAC recommendations for Discovery. On the New Frontiers program, the SSES recommended that NASA use science definition teams and technology definition teams to refocus science goals and advance immature technologies for the four medium-class decadal survey missions still to be selected.

With respect to the Mars Exploration Program, the SSES commented on the balance between science expectations and resource constraints for the Mars Science Laboratory (MSL), especially with regard to completing development of the various instruments while addressing the planetary protection issues of both bioload and landing radioisotope thermoelectric generators (RTGs) on the martian surface. The SSES approved of the Mars Exploration Program Analysis Group (MEPAG) plan for addressing the MSL issues. The SSES saw the MEPAG's Next Decade program for Mars as an excellent response to the challenge from the Office of Management and Budget (OMB) to develop a post-MSL plan for exploring Mars. Dr. Lunine described how operational and planned missions through the remainder of this decade will prepare for the four exploration pathways proposed in the Next Decade Plan. Overall, the SSES judged the Next Decade Plan to be sensible, but it recommended that Scout mission proposers not be constrained to a particular exploration pathway.

The SSES had been briefed on the NAI and raised several issues with regard to cooperation among science teams, while commending the institute's use of focus groups and extensive field programs. On the Planetary Data Service (PDS), the SSES wrote that current NASA plans for it may not be aggressive enough in developing an integrated data system and associated tools to support the science community in using PDS data. However, the associated tools need not be developed by the PDS project. For instrument development to support planetary missions other than Mars exploration, the SSES expressed concern that OSS lacks technology program support for instrument development through the mid Technology Readiness Levels (TRLs). Cost-capped mission program lines would particularly benefit from a mid-TRL instrument development program as a form of mission risk reduction.

In response to Dr. Christensen, Dr. Lunine said that the recommendation on science definition and technology definition teams for the New Frontiers program might be an item for SScAC action. SScAC members discussed issues in Mars exploration beyond 2009 and the impact of MSL planning decisions on the four exploration pathways.

Dr. McComas summarized the SECAS report to SScAC (full report in Appendix F). The SECAS repeated its strong endorsement of the Space Technology 5 (ST-5) mission. ST-5 will flight-validate mission-critical elements for the Magnetosphere Constellation and other multi-spacecraft missions in the Space Technology Program queue. It is the only planned ST project that does not include launcher cost in its budget, as the program initially assumed that launch as a secondary payload would be available. In light of the lack of such opportunities, the SECAS recommended that the New Millennium program purchase a Pegasus vehicle for launching ST-5. Dr. McComas asked SScAC to support this SECAS recommendation. Based on its discussion with Project Prometheus staff, the SECAS recommended that an Interstellar Probe mission be added as the second Prometheus mission after JIMO and expressed interest in greater representation of the Sun–Earth Connection science community on the Prometheus Science Concept Definition Team (SCDT).

After discussion, SScAC agreed to concur with the SECAS recommendation on ST-5. On Project Prometheus, Dr. Allen noted that the NRC's Space Studies Board will be studying post-JIMO science opportunities using the program's technologies and will report in March 2005. Input to the Prometheus SCDT was also discussed.

Dr. Spergel summarized the OS report to SScAC (Appendix E). The OS agreed with the concerns expressed by the Astronomy and Physics Working Group (APWG) about the proposed separation of research and analysis (R&A) funding in the APD into separate lines for the Structure and Evolution of the Universe and Astronomical Search for Origins themes. It asked SScAC to concur in recommending against the separation. Another concern was funding cuts for technology development for the Terrestrial Planet Finder (TPF) mission. (Dr. Charles Beichman did not participate in the discussion about TPF because of potential conflicts.) Dr. Kinney explained the administrative driver behind the separation of R&A into two funding lines. In response to a question, Dr. Spergel explained that the technology concern for TPF is about midlevel technology development for major instruments. Dr. Kinney described factors that were jeopardizing the TPF budget.

Dr. Kolb summarized the SEUS report to SScAC (Appendix G). After reviewing the relationships among the three elements of the Beyond Einstein initiative, he discussed the status of the support from the DOE for JDEM and the theoretical issues that make the Dark Energy Probe important. The cost of an Einstein Probe mission is expected to be more than an Explorer mission but less than a strategic mission. Dr. Kolb answered questions from SScAC members on the relation of the DOE's work on SNAP to JDEM and the DOE's acceptance of NASA's approach to a peer-reviewed competition for JDEM and public access to the data after a proprietary period. Members asked the SEUS to emphasize the importance of full and open competition and early availability of the data as the subcommittee continues to follow the Einstein Probes activities.

NASA Astrobiology Institute Director Selection

Mr. Scott Hubbard, ARC Director, briefed SScAC on the process leading to selection of the new director of the NAI, Dr. Bruce Runnegar. Part of that process was a commitment to inform the astrobiology community of the difficulties encountered in satisfying all the community interests and procedural constraints in selecting and approving the new director. This briefing is part of that communication requirement. The search committee, which wanted an active astrobiology researcher as the new director, reviewed applications received through a solicitation process, as well as through suggestions of candidates from the search committee members. Dr. Runnegar was the committee's unanimous top candidate, but as head of one of the NAI science teams, he also had a potential conflict of interest under 18 USC Section 208. Any of the other competitive

candidates would have been in the same situation. After trying several approaches in consultation with the NASA Office of General Counsel, the last recourse was to request a waiver from the NASA Administrator and propose a formal plan for mitigating any conflicts of interest. Mr. O'Keefe signed the waiver and mitigation plan. The plan includes informing the community about the situation and waiver, dividing the scientific leadership (director position) from NAI operational management, and conducting semiannual ethics surveys. Mr. Hubbard described other aspects of the mitigation plan and discussed the rationale in the waiver request for why the next NAI director can reasonably be expected to not have this conflict.

During the lunch break, Dr. David Des Marais of ARC gave a talk on investigating the geological record of the Earth's early biosphere as a tool for planning the search for signs of extraterrestrial life. Dr. Chris McKay of ARC spoke about planning the search for signs of life on Mars.

Report of the JIMO Science Definition Team

Dr. Torrence Johnson of the Jet Propulsion Laboratory (JPL) and Dr. Ron Greeley of Arizona State University, cochairs of the JIMO Science Definition Team (SDT), reported on the work of the team, which has 38 members. To begin with, all of the satellites in the Jupiter system were under consideration. The mission as currently planned will contribute to portions of eight of the twelve objectives of the NRC solar system decadal survey and five of eleven non-Mars science objectives in the NASA Solar System Exploration road map. A general philosophy on which the team agreed was that the large investment in funds, time, and intellect for the JIMO mission demands a commensurate high scientific yield. Also, JIMO will be setting a framework for subsequent Project Prometheus missions. To gather input from the science community, an open forum was held in Houston. The SDT also worked closely with Project Prometheus engineers to define mission characteristics and the payload accommodation envelope. Next, the SDT defined a hierarchy of JIMO goals, objectives, investigations, and measurements needed for the investigations. The team defined a JIMO baseline mission and a science floor. Dr. Greeley reviewed the four science discipline goals (goals in the areas of surface geology and composition, interior science, astrobiology, and Jupiter system science) and the objectives under each goal. From this level of analysis, the SDT derived three themes that cut across the discipline goals: oceans and active internal processes, astrobiology (volatiles, organics, and chemical processes), and jovian system interaction processes (satellites, atmospheres, surfaces, and interiors). Next, Dr. Johnson described how the capabilities of nuclear electric propulsion (NEP) enable revolutionary science to be performed by the JIMO mission. In addition to enabling data transmission rates a hundred-fold greater than current levels, the high power levels enable new types of investigations, increased capability of investigations, and more-capable instruments. He illustrated the differences by comparing the resolution and surface coverage attainable by Voyager, Galileo, and the planned JIMO spacecraft.

Dr. Johnson discussed the SDT's principal recommendations for JIMO. The initial science payload estimate of 600 kg was judged to be inadequate for the science floor, and the SDT recommended increasing the baseline payload to 1,500 kg. The SDT recommendation for high inclination (greater than 70º around the moons) led to discussion with SScAC of desirable orbital characteristics, including time in orbit. A separate meeting, held at ARC, on an auxiliary package to be landed on the surface of Europa led to assigning 25 percent of the payload resources to this package. The SDT developed a priority list of objectives and measurements for this Europa Surface Science Package. However, an engineering study is needed to determine how much of this list is feasible. The SDT recommendations are being presented to and discussed with the Space Studies Board of the NRC, its Committee on Planetary Exploration (COMPLEX), and a special session of the American Geophysical Union, in addition to this presentation to SScAC.

The SScAC members asked the presenters about the accommodations for the radiation environment near Jupiter, the relation of the SDT's mission analysis to the Prometheus/JIMO high-power instrumentation NRA, and the continuing relationship between the science development side for JIMO and Project Prometheus NEP technology development. In response to a question about political support for NEP, Dr. Weiler said that the history of congressional support for Project Prometheus and JIMO indicates a shift toward support for nuclear alternatives in space missions. The members and guests also discussed the importance of continued interaction between the Project Prometheus program office and the science community on both JIMO and planning for subsequent Project Prometheus missions. Dr. Christensen ended the discussion with a comment on the positive response to the SDT's approach and results.

Selection of Future Science Centers

(Dr. Charles Beichman recused himself from the presentation and discussion on science centers.) Dr. Anne Kinney described the selection processes that have been used for the three classes of science centers. A science center for an Explorer-class mission is proposed by a PI as part of the overall Explorer mission package. The second type of center is one established for collaborations led by foreign partners. Dr. Kinney interpreted the August 2003 SScAC recommendation on competing science centers in the future as applying to the third type: science centers for observatory-class missions. Of the science centers in this category, two were competed and two were assigned by NASA Headquarters. Neither of the two most recent centers was competed. The Chandra X-ray Center (CXC) was competed initially, then the contract was renewed noncompetitively in FY 2003. The Michelson Science Center, which was assigned by NASA Headquarters to JPL, is small at present ($8.5 million per year, full-cost accounting) but will grow as the TPF mission develops. It also supports the Keck Interferometer, Large Binocular Telescope Interferometer (LBTI), SIM, and the archive for the Keck Interferometer. The SIRTF Science Center was assigned by NASA. The Space Telescope Science Institute (STScI), which supports the HST now and will support the JWST after 2011, was competed originally, with the contract renewed non-competitively. Dr. Kinney discussed the number of full-time equivalent scientific staff at each of the four centers, including the number tenured for the duration of the contract. She then listed reasons for and against initial competition of the contract for a center and the issues in recompeting centers once established.

In response to a question, Dr. Kinney said that NASA has no distinct plan for ending a contract for a science center. Recompetition is likely to affect the management organization, but not necessarily the bulk of center personnel. Usually, many of the center personnel move from the old site to the new one. However, recompetition implies that some existing staff could be laid off if the contractor changes. Particularly for the larger science centers, this can have substantial political and social ramifications. There may also be an issue of mission safety if a spacecraft is operating during the transition. Only rarely does OSS create a new science center of the third type, and there is no formal documentation of a process for creating one.

Dr. Martin Kress summarized the process as proceeding by various routes, depending on the size of the center being created and other factors. He suggested that an announced competition might lead state authorities and academic institutions to make proposals that could be in NASA's interest. A policy on competing science centers could aid in getting the maximum science value from NASA's investments in them. Dr. Garth Illingworth added that the OS had been concerned about the assignment of both SIM and TPF to the Michelson Science Center without a competitive process. Dr. Spergel added that the OS view was that the science centers associated with SIM, TPF, and JWST should be competed, rather than assigned. Members discussed with Dr. Kinney the benefits and costs of competing placement of centers and the reasons for placing the early TPF work with the Michelson Science Center. Dr. Christensen asked the OS to take up

the issue of competing the science centers again, as none of the other science disciplines are involved with them at this time. SScAC agreed with the chair's suggestion.

General Committee Discussion and Letter Drafting

SScAC discussed drafts for a recommendation on HST servicing and end-of-mission planning. (Dr. Weiler left the meeting during the committee's discussion of alternative HST recommendations.). SScAC generally agreed with the set of six findings drafted by Dr. Christensen, with some revisions. A stronger statement in support of the Discovery and Explorer missions was discussed. Several members asked for further information on HST deorbiting options at a future SScAC meeting. Dr. Christensen said that the compromise language resulting from the discussion would be combined into a clean draft and distributed by email to the members for further comment and eventual approval. Other issues on which recommendations were discussed included JIMO and the SDT, the MESSENGER mission status and the changes in the Discovery Program, and endorsement of the SECAS proposed recommendation on a launch vehicle for ST-5. Draft language for a recommendation on instrument technology development for JIMO and MSL was discussed. On the question of honoraria for review panel members, SScAC favored the status quo but agreed to examine the issue further.

Subcommittee Guidelines and Procedures

Dr. Allen presented a set of draft guidelines for the SScAC subcommittees and the procedure for bringing their findings and recommendations before SScAC. Membership of the subcommittees is established through nominations derived within the OSS divisions. Dr. Allen discussed with SScAC a nomination and approval process to ensure broad and balanced representation of the appropriate disciplines on the subcommittees. The subcommittees will meet three to four times yearly for 1.5 to 2.5 days at each meeting. Meetings will generally be open to the public, but subcommittees or subsets can meet by teleconference, since they are not FACA committees. Dates and location of meeting are posted on the OSS web site 30 days in advance and announced in the *Federal Register.* A procedure for public comment at meetings was discussed. The findings and recommendations from a subcommittee meeting will be presented in a letter to the SScAC chair. After the letters have been transmitted to the chair, they will be posted on the OSS/SScAC web site for public access. A signed paper copy should be forwarded to Code S for record-keeping purposes. Dr. Allen suggested that the subcommittee reports include an attachment summarizing any recommendations for action by SScAC. Transmission of the subcommittee letters to the SScAC membership was discussed. Other topics of discussion were membership constraints and the requirements for nomination slates.

Briefing to the Associate Administrator for Space Science

Dr. Christensen described to Dr. Weiler SScAC's views on the scenarios for HST end-of-mission planning and HST servicing. He said that the committee's written recommendations will address both SM-4 and SM-5. (See Appendix J for the SScAC letter to Dr. Weiler.) Dr. Christensen then summarized the elements in the six points on which SScAC had agreed. Dr. Weiler reviewed some of the issues underlying the importance of performing SM-4 as early as possible. Dr. Christensen said SScAC would endorse the suggestion by the OS to use an Origins NRA as the beginning of a strategic planning process within which SM-5 could be evaluated. SScAC will also commend the JIMO SDT for its work. Appropriate timing for an AO on JIMO instruments and representation of the science disciplines on the Project Prometheus SCDT were other items discussed with Dr. Weiler. Dr. Christensen expressed the pleasure of SScAC in the NASA responses to the recommendations on the Discovery program and MESSENGER. He noted that SScAC would concur with the SECAS recommendation on procuring a Pegasus to launch ST-5. Dr. Christensen adjourned the meeting at 5:15 p.m.

AGENDA
SPACE SCIENCE ADVISORY COMMITTEE
November 17–18, 2003
NASA Ames Conference Center, Building 3, Ball Room
NASA Ames Research Center
Moffett Field, CA

17 November

8:30	Center Director's Welcome	S. Hubbard
8:45	Chair's Remarks	A. Christensen
9:00	Ethics Briefing	K. Kouba
9:45	AA's Introduction and Q&A	E. Weiler
10:45	BREAK	
11:00	Bahcall Panel Report Summary and Q&A	C. McKee
Noon	LUNCH: Science Talk on RHESSI	R. Lin
1:00	A&P Division HST Issue Presentation and Q&A	A. Kinney
1:30	Subcommittee Recommendations on HST and Discussion	D. McComas J. Lunine D. Spergel R. Kolb
2:30	Division Director Comments on HST and Q&A	A. Kinney R. Fisher O. Figueroa
3:00	BREAK	
3:15	Public Comment	A. Christensen
3:45	Committee Discussion	A. Christensen
5:00	Status of Sounding Rocket Program	R. Fisher
5:30	ADJOURN	

18 November

8:00	NASA Advisory Council Issues	A. Christensen
9:00	Honoraria for Peer Review Panel Members	D. Bohlin
9:30	Update on MESSENGER and Cost Cap Issues	O. Figueroa
10:00	BREAK	
10:15	Subcommittee Recommendations on Non-HST Issues	D. McComas J. Lunine D. Spergel E. Kolb
11:45	Astrobiology Director	S. Hubbard
Noon	LUNCH: ARC Astrobiology Science Talks	D. Des Marais C. McKay
1:00	General Committee Discussion	A. Christensen
2:00	Subcommittee Guidelines and Procedures	M. Allen
2:15	Report of the JIMO Science Definition Team	R. Greeley
3:00	BREAK	
3:15	Selection of Future Science Centers	A. Kinney
3:45	General Committee Discussion and Letter Drafting	A. Christensen
5:15	Briefing to AA with Q&A	A. Christensen
6:00	ADJOURN	

SPACE SCIENCE ADVISORY COMMITTEE (SScAC)
MEMBERSHIP LIST

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Fermi National Accelerator Laboratory

Mr. Martin P. Kress
Battelle Memorial Institute

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Southwest Research Institute

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SPACE SCIENCE ADVISORY COMMITTEE
November 17–18, 2003
NASA Ames Research Center
Moffett Field, CA

MEETING ATTENDEES

Committee Members:

Christensen, Andrew, *Chair*	Northrup Grumman Space Technology
Allen, Marc, *Executive Secretary*	NASA Headquarters
Beichman, Charles	NASA/JPL
Deamer, David	University of California, Santa Cruz
Grindlay, Jonathan	Harvard-Smithsonian Center for Astrophysics
Hammel, Heidi	Space Science Institute
Harrison, Fiona	California Institute of Technology
Heelis, Roderick	University of Texas at Dallas
Illingworth, Garth	University of California, Santa Cruz
Karpen, Judith	Naval Research Laboratory
Klein, Andrew	Oregon State University
Knappenberger, Paul	Adler Planetarium and Astronomy Museum
Kolb, Edward "Rocky"	Fermi National Accelerator Laboratory
Kress, Martin	Battelle Memorial Institute
Lunine, Jonathan	University of Arizona
McComas, David	Southwest Research Institute
Mould, Jeremy	National Optical Astronomy Observatory
Mustard, John	Brown University
Spergel, David	Princeton University
Thomsen, Michelle	Los Alamos National Laboratory

NASA Attendees:

Bohlin, David	NASA Headquarters
Burch, Preston	NASA/GSFC
Desilvestre, Ingrid	NASA/ARC
Figueroa, Orlando	NASA Headquarters
Fisher, Richard	NASA Headquarters
Friedland, Peter	NASA/ARC
Hubbard, Scott	NASA/ARC
Johnson, Torrence	NASA/JPL
Kinney, Anne	NASA Headquarters
May, Lisa	NASA Headquarters
McKay, Chris	NASA/ARC
Moore, Michael	NASA Headquarters
Nelson, Robert M.	NASA/JPL
Norris, Marian	NASA Headquarters
Sadhurani, Komal	NASA/ARC
Smith, Eric	NASA Headquarters
Taylor, Ray	NASA Headquarters
Thronson, Harley	NASA Headquarters
Wiseman, Jennifer	NASA Headquarters

NASA Attendees, continued

Woods, Dan	NASA Headquarters

Other Attendees:

Bauer, David	NGST
Beckwith, Steven	AURA/Space Telescope Science Institute
Black, David	USRA
Davidoff, Larry	Boeing
Dewhurst, Brian	NRC
Greeley, Ron	Arizona State Univ.
McKee, Christopher	Univ. of California, Berkeley
Kaplan, Mike	Boeing
Katt, Robert	RS Information Systems, Inc.
Kopplin, John	Spectrum Astro
Lin, Robert	Univ. of California, Berkeley
Margon, Bruce	Space Telescope Science Institute
Purdy, William	Ball Aerospace
Whitehead, Debra	no affiliation

SPACE SCIENCE ADVISORY COMMITTEE
November 17–18, 2003
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LIST OF PRESENTATION MATERIAL[1]

1) Andrew Falcon, NASA Office of General Counsel, *Ethics Briefing for Special Government Employees Serving on NASA Advisory Committees.*
2) Edward J. Weiler, Office of Space Science, *NASA Space Science: An Update*. November 2003.
3) Christopher McKee, Handout on the HST-JWST Transition Panel and report.
4) Letter of 16 November 2003 from the HST-JWST Transition Panel to Dr. Andrew Christensen, Chair, Space Science Advisory Committee.
5) Steven Beckwith, AURA/Space Telescope Science Institute, *Hubble Science with Delayed Servicing*.
6) Anne Kinney, Astronomy and Physics Division, NASA Office of Space Science, *Astronomy and Physics Division Overview Presented to the Space Science Advisory Committee*.
7) Anne Kinney, Astronomy and Physics Division, NASA Office of Space Science, *HST Lifetime and End-of-Mission Scenarios.*
8) David Spergel, Chair, Origins Subcommittee, *Future of HST.* Presentation slides on HST recommendations of the OS.
9) Edward Kolb, Chair, Structure and Evolution of the Universe Subcommittee, "SEUS HST Recommendations" (one page).
10) David McComas, Chair, Sun–Earth Connection Advisory Subcommittee, *SECAS Report to SScAC*.
11) Jonathan Lunine, Chair, Solar System Exploration Subcommittee, *Summary of SSES Meeting, October 2003*
12) Orlando Figueroa, Director, Solar System Exploration Division, *.Discovery Program: MESSENGER, Deep Impact, and Beyond*.
13) David Spergel, Chair, Origins Subcommittee, *Origins Subcommittee Report.*
14) Marc S. Allen, NASA Office of Space Science, *Subcommittee Guidelines and Procedures*, Draft, 18 November 2003.

[1] Presentation and other materials distributed at the meeting are on file at NASA Headquarters, Code S, Washington, DC 20546.

Letter from the Chair, Origins Subcommittee, to the Chair, Space Science Advisory Committee

November 16, 2003

Dear Dr. Christensen,

The Origins Subcommittee met at the University of Maryland in October 2003. This letter summarizes our meeting and discussions.

(1) Recent Progress

Anne Kinney briefed the OS on the status of Origins missions. The recent successful launch of SIRTF promises a very exciting period for origins science. SIRTF observations will address a broad range of scientific problems related to Origins science.

Both SIM and JWST have just entered phase B. Both missions are technically challenging and scientifically promising. The OS congratulates the SIM and JWST teams on their successful technological developments.

(2) SM4.

The OS heard a presentation by Dr. Kinney of the APD plan to complete SM4. Our consideration of this plan is as follows.

A critical component of the SM4 mission is the replacement of gyros and batteries, without which normal operation of HST is expected to fail during 2006, and the 2-gyro operation mode (currently being developed), is expected to last only an additional 15 months. We support investments to enhance the lifetimes of future gyros. The orbit re-boost that is also part of SM4 will increase the useful life of HST
and delay the time when HST must be de-orbited.

Two new instruments, the Cosmic Origins Spectrograph (COS), and Wide Field Camera 3 (WFC3), which are part of the SM4 mission, will add new capability for HST: factors of several tens in efficiency for Far UV spectroscopy (COS), and pan-chromatic imaging from the near UV through near IR (WFC3), through an extensive complement of filters. These instruments are at the forefront of the Origins theme, and the OS is excited at the new observations that they will enable.

Maximal utilization of HST and of the new discovery space opened by the two new instruments is achieved by executing SM4 as early as possible. If SM4 turns out to be the last refurbishment of HST, this represents the last opportunity to conduct science in the UV with a large optical telescope.

Therefore the OS endorses the APD plan to carry out SM4 as soon as possible.

(3) De-orbit.

The OS heard Dr Kinney's presentation of the plan to de-orbit HST. Our response to this plan is as follows.

We agree that considerable uncertainty attends future flights of the Shuttle. We also recognise the necessity to bring HST out of orbit at the end of its useful life without unnecessary danger to people. We did discuss alternative options including a slow boost to escape orbit, or a boost to a long-term parking orbit. To develop points of comparison, we asked what provisions have been made, or will be made, to de-orbit other large spacecraft, including the International Space Station. We returned to the proposed APD plan to send up an autonomous mission to attach an upper stage to HST so that it could be safely driven out of orbit in an unpopulated area.

The OS concurs with the NASA plan to develop the capability to deorbit HST with a propulsion module. We encourage NASA to seek separate funding for the propulsion module development, so that it will not adversely affect the development or operations of other scientific missions. We would like to be briefed on the propulsion-module development at an upcoming meeting.

(4) Origins Probes.

At this and its previous meeting, the OS considered the issue of the lack of mission opportunities for anticipated spacecraft that would address the Origins theme. Our discussion follows.

At present, all Origins experiments can be proposed for flight under the Explorer lines and planetary missions can be proposed under the Discovery line, with cost capping of $250 and $325M respectively. We believe there are many exciting Origins science questions that can not be addressed within these cost caps including searches for extra-solar planets, studies of the emergence of elements and structures, studies of galaxy formation and astrobiology missions. Many of these missions require cryogenic technologies or large optics both of which are expensive. We believe that the only way to carry out important Origins science is to have available a mission line dedicated to Origins experiments, with an appropriate cost cap. For this letter, we define these new missions as "Origins Probes".

We understand that it takes time to establish a new funding line. Therefore the OS recommends that APD investigate mechanisms to initiate the study of possible missions and encourages the astronomy community to consider the range of missions and science questions that these missions might address in the coming decade. We envision discussing this line in the upcoming strategic planning process.

(5) SM5

The OS spent a substantial fraction of its meeting discussing SM5. Our thoughts follow.

The committee strongly endorses the opinion of the 2000 NRC Decadal Study (Astronomy and Astrophysics in the New Millennium) that “recommends that NASA maintain diversity in its flight programs by ensuring that a suite of opportunities, including small, moderate, and major missions, is available to accomplish scientific goals.” We also note that the 1990 Decadal Study (The Decade of Discovery in Astronomy and Astrophysics) recommended an increase in the “rate of Explorer missions for astronomy and astrophysics to six Delta-class and five SMEX missions per decade.” Explorer line should not stand down for a large fraction of a decade to pay for SM5 plus continued HST operations.

The HST/JWST Transition Panel, chaired by John Bahcall, calls for a procedure to “determine the value of a future science-enabling SM5” that would include a peer reviewed competition of SM5 proposals against each other and “in competition with other comparably sized new scientific proposals such as those within the Explorer or Discovery programs.” That panel clearly stated its

opposition to adverse impact on “already approved science projects,” and its intention “to maintain the relative priorities of the Decade Surveys.”

We, along with APD, find it quite difficult to imagine a practical way to hold a fair and open peer competition which selects between Explorer Missions costing as little as $120M and a two-instrument SM5 including GO support which we were told would cost between $556M and $1228M, depending on its scope. This cost does not include launch costs nor does it include the risks associated with Shuttle delays.

We believe that a solution lies in studying possible Origins Probe missions and possible instruments for SM5. If funding does eventually become available, these ideas could compete to be the next major initiative in the Origins program.

To carry this out, the APD should issue an NRA for vision concept studies for Origins Probes or HST. These missions, which could be costed at the same level as the HST project's estimates of SM5, i.e. $556M to $1.2B, could include missions utilizing instruments to be added to HST via SM5, as well as missions to be launched on an ELV. These vision concept studies should be peer-reviewed. The results of these studies will serve as key inputs to the strategic planning process.

These studies could be used to argue for new money for the origins theme from outside OSS. We find that the only way to implement the highest ranked recommendation of the Bahcall Committee, i.e., to hold SM4 and SM5, if scientifically valuable, is to find new money. The Bahcall Committee noted that if an SM5 was found to be scientifically justified "...that the Administrator should find a way to fund the required Shuttle-related costs out of the entire NASA budget (not just out of the OSS budget)." In the event that SM5 were to win a peer-reviewed competition as suggested above, the differential cost of a shuttle mission (as compared to an ELV in the other cases) should also be sought as incremental funding for OSS.

Since there are no funds available for any of these proposals, we note that it is not likely that APD would be able to compete new instruments for SM5 against these alternatives in time for a 2010 servicing mission. The committee is endorsing the APD decision to not have a servicing mission in 2010. If there are significant delays in JWST, so that for example, a 2015 launch looks likely, then a servicing mission in 2012 or later might become an attractive possibility. We hope that by engaging the community in an exploration of possible instruments or alternative missions, the APD could be responsive to the recommendation of the Bahcall committee.

The OS and SEUS heard a report on the DOE/NASA plan to cooperate on a Joint Dark Energy Mission. Since HST could potentially carry out much of the proposed JDEM science, we encourage DOE and NASA to consider incorporating JDEM in a proposed SM5 competition. We suggest that the AAC consider this possibility in its next meeting.

We strongly endorse the spirit of the Bahcall Committee recommendations: SM5 mission should proceed if it is the most scientifically compelling of comparably sized initiatives, and only if the winner of those initiatives is sufficiently exciting that new funds are generated for OSS. We also strongly endorse the Bahcall committee recommendation that the first priority for the APD is to carry out missions already identified in the decadal surveys and the strategic plans. New initiatives, such as the Origins Probes and SM5, will require review in the strategic planning process and by the CAA.

Therefore the OS recommends that APD engage the community in the process of developing new concepts for Origins Probes and for possible SM5 instruments.

(6) Shift in the Structure of R&A Funding

The Origin Committee heard a report from the APWG on a shift in the structure of R&A funding. The APWG sees serious problems with the pending decision to divide R&A funding into separate SEU and ASO budget lines. Such a division would arbitrarily assign research programs to one category when they may actually fall into the other, and this could prevent excellent programs from being eligible for funding. For example, a theory proposal to study star formation might not be supported because no theory funding would be available under the ASO line; or a proposal to develop UV technology in support of cosmological research might not be funded because it is SEU science but all UV supporting research must be funded under ASO. The Origins Committee recognizes the value of a broadly based technology development effort and a broad based theoretical effort to support future, unidentified mission concepts, as well as mission items identified in the strategic plan. The committee is concerned that selection criteria defined on the basis of a limited list of specific scientific inquiries are inappropriate for a broad technology development effort. In short, the planned separation of SEU and ASO funding creates artificial and unnecessary barriers to funding the best and broadest science. It also creates new bureaucratic burdens for the NASA administrators who manage R&A programs. We encourage SScAC to oppose this restructuring.

Sincerely yours,

David Spergel for the Origins Subcommittee

Letter from the Chair, Sun–Earth Connection Advisory Subcommittee, to the Chair, Space Science Advisory Committee

Dr. Andy Christensen, Chair
Space Science Advisory Committee

RE: SECAS Meeting, 4-6 November 2003

Dear Andy,

The Sun-Earth Connection Advisory Subcommittee (SECAS) was happy to meet and review the state of the Office of Space Science (OSS) Sun-Earth Connection (SEC) Division and theme in Washington D.C. on 4-6 November 2003. We were delighted to find that SEC continues to be generally healthy as it aggressively pursues a broad-based range of research and flight programs aimed at understanding fundamental space physics phenomena from the interior of the Sun to beyond the outer reaches of the heliosphere: a program that is not only developing a great many new insights into these fundamental phenomena, but also discovering their effects on life and society.

In keeping with our previous reports, this letter will focus only on the top few issues that need special or urgent attention. We hope that this format of highlighting the most crucial areas that come out of each meeting spotlights their importance and helps OSS and SEC focus their limited resources on these most critical areas.

HST Transition and Explorer Program

SECAS has carefully reviewed and affirms the essential importance of the Explorer program to SEC disciplines. This position is further supported by OSS's own 2003 Space Science Enterprise Strategy that states: **"NASA's Explorer Program is an example of the mission lines that are vital to realizing the Enterprise's science objectives."** (NASA Space Science Enterprise Strategy, Oct. 2003, p. 14) In addition the current Strategic Plan makes explicit that *The Explorer Program offers frequent opportunities to carry out small- and medium-sized community-based missions (SMEX and MIDEX) that can be developed and launched in a short (approximately four year) timeframe.* (Strategic Plan, op cit, p. 14)

SECAS is incredulous that the HST-JWST Transition Panel Report could suggest options for additional HST servicing that would involve diverting the entire Explorer line for a significant time, thus subverting the critical and unique role of the Explorer Program. Further, SECAS finds that any disruption of Explorer program resources, as in HST servicing options that place a single very large mission in competition with the fundamentally different intent of the line of Explorers, would have a drastic negative impact on the SEC program. In our view, such options are in stark conflict with past practice (including, we believe, congressional intent), as well as with the just published OSS Enterprise Strategy.

Further, SECAS notes that:

(1) SEC Explorers are responsible for major scientific achievements that have profoundly transformed understanding of the Sun-Earth system. Some highlights include: visualization of the global dynamics of the geospace system by IMAGE, the multidimensional views of solar activity by RHESSI, discovery of coronal magnetic complexity by TRACE, discovery of trapped

anomalous cosmic rays in Earth's magnetosphere by SAMPEX, and discovery of fine scale nonlinear kinetic auroral structures by FAST.

(2) Cost-effective Explorers are an integral part of a distributed fleet of spacecraft needed for study of SEC science. The assumption of a vital Explorer program is so fundamental (see Solar and Space Physics (SSP) Survey, Figure ES.1-ES.2, p. 8-9) in planning SEC science that the SSP survey committee declined to prioritize a mission if it was "gauged to be feasible within the resources of the Explorer program" (SSP Survey, p. 58). Consequently, phasing and planning of SEC missions would be severely disrupted if the Explorer budget is diverted in any significant way.

(3) The recurring opportunity to develop Explorer missions is an essential part of the SEC science strategy and provides creative input into the Space Physics Enterprise that cannot be anticipated in strategic mission lines. The SSP Survey Committee recognizes this, stating, "The Explorer program has long provided the opportunity for targeted investigations, which can complement the larger initiatives recommended by the committee." (SSP Survey, p. 62). The SSP Panel Reports (in press) echo this priority, for example, the Atmosphere-Ionosphere Magnetosphere (AIM) Panel recommends that "SMEX and MIDEX programs should be vigorously maintained". (SSP AIM Report, Rec. #2).

(4) Explorers provide hands-on training of instrumentalists, both scientists and engineers, thus enabling SEC strategic missions, and directly contributing to the Agency Mission "to inspire the next generation of explorers". Interrupting the program would cause a future shortage of required expertise. The SSP Survey assumes that the Explorer program will be maintained, and in addition recommends "Revitalization of University-Class Explorer program for more frequent access to space for focused research projects". (SSP Survey, p. 7)

(5) Managing cost-constrained missions such as Explorers requires specialized expertise and continuity of experience that would be disrupted, SECAS believes permanently, by the interruption of the Explorer program.

(6) According to the SSP Survey Committee (p. 156), the PI class Explorer is a model for efficient, rapidly deployed, smaller scale space science missions.

The above conclusions are strongly held in the SEC community as exemplified by recent MOWG findings. The LWS MOWG "finds that it would be unwise to use Explorer budgetary authority to pay for Hubble Space Telescope refurbishment or mission extension". The Geospace MOWG opposes reallocation of Explorer funds across Divisions, and warns that "the consequences of executing the extended HST mission instead of several Explorer missions are severe" and would lead to a "high level of risk to a very productive program". Likewise, the Solar and Heliospheric MOWG finds that "the particular approach of competing the (HST) servicing mission against the line of future Explorer missions does not, in the view of the SH-MOWG, constitute such (an acceptable) solution".

Finally, spectacular recent results from WMAP and other missions show that the value and public visibility of Explorers are not limited to SEC science but apply broadly across astrophysics and space science. Therefore, we suggest that it is in the interest of NASA strategic goals across the disciplines, to protect, and if anything expand, the resources available for the Explorer program.

Resolving the ST-5 Flight Crisis

SECAS continues to endorse strongly the ST-5 project as a vital path-finding flight program for Sun-Earth connection missions requiring resource-limited satellites. The three-spacecraft ST-5 flight mission will validate mission-critical elements needed urgently for Magnetospheric Constellation and the many other multi-spacecraft SEC missions in the STP queue, as well as those being developed as PI-class Explorer missions. Prompt flight validation of ST-5 is required in order to provide timely and vital risk reduction for SEC missions now in pre-formulation.

ST-5 will demonstrate that:
1. Resource-limited satellites, employing and validating new technologies and capable of research-quality measurements, can be designed, built, and flown;
2. Economy of scale in the fabrication of multiple, small satellites can be established credibly;
3. Technical issues associated with the operation of a trail-blazing constellation can be explored and assessed in flight.

When ST-5 was selected in 1999, the hope was that a very inexpensive ride-of-opportunity could be found to assure a flight validation by 2004. Despite due diligence by program officials, no such ride has been identified, thus now putting the important ST-5 flight validation at serious risk. We note that all ST flight projects beyond ST-5 have baselined the cost of an appropriate launcher into their budget to ensure flight validation. Specifically, adequate resources for access to space are committed for ST-6, ST-8, and ST-9. However, ST-5 presently has no budget to purchase such access to space, leaving its flight validation in limbo and jeopardizing future missions dependent upon its completion. We believe this inequity is unjustifiable.

To ensure the realization of critical SEC-mission-enabling goals, SECAS reaffirms its earlier strong recommendations (August 2001 and February 2003) to complete the ST-5 flight project and recommends that NMP immediately purchase a dedicated Pegasus launch in order to assure that critical SEC technologies will be validated promptly. As a result of this rebudgeting, SECAS considers the consequential delays of ST-10 and ST-11, each by one year, to be an acceptable and equitable programmatic trade.

SEC Interactions with Project Prometheus

Interstellar Probe (IsP) is an extremely ambitious and compelling future SEC mission to move beyond the limits of the solar system and explore the nearby galaxy *in situ*. Dependable and cost-effective nuclear power providing comparatively large and long-duration propulsion, implemented in a straightforward manner without significantly affecting scientific measurements, would greatly facilitate bringing the IsP mission to reality. Thus, SECAS suggests the addition of IsP to the Prometheus mission line as a second mission goal after Jupiter Icy Moons Orbiter (JIMO). Further, while existing technologies are sufficient for other SEC missions such as Solar Probe and Telemachus, systems being developed by Prometheus may significantly benefit those missions by providing additional flexibility, weight and cost reductions, or systems tailored for specific mission needs. SECAS therefore recommends that the Prometheus Project explore and report how nuclear propulsion technology developments enhance planned and future notional SEC missions. Finally, although there is now an individual from the SEC community on the Prometheus MOWG, SECAS feels that additional SEC representation would greatly enhance the interactions and future collaboration between SEC missions and capabilities developed in Project Prometheus

Vigilance in Cost Control

In light of several recent examples of cost growth in NASA science missions, SECAS endorses the principles embodied in the retirement of risk (including cost risk) at an early stage of the Magnetospheric Multi-Scale (MMS) Mission by increasing the time and resources allocated for the Phase A study to enable a more accurate cost and feasibility assessment by each of the proposing teams. We also reiterate the very high importance we place on holding down program costs in the interest of maintaining a healthy cadence of missions. Maintaining the planned mission timing is particularly crucial for the LWS program, where the target system-level science requires some overlap in the operations of different satellite elements and/or a particular phasing relative to the solar cycle. We are particularly concerned about cost increases in SDO, which have placed in jeopardy both the timing of subsequent LWS missions and the accommodation of a coronagraph, which is judged by our LWS MOWG to be a very important system-level instrument. We encourage Headquarters and program management to reassess the cost drivers for SDO and to seek a mechanism to return coronagraph capability to the LWS program without increasing costs or compromising the schedule or the rest of the science measurements.

Expanded Role for the LWS MOWG

An integral component of LWS has been to enable science that cuts across disciplines and mission boundaries in order to achieve understanding of the Sun-Earth system, and to deliver scientific advances that have demonstrable relevance to life and society. SECAS asks the LWS MOWG to help oversee this activity by using its broad and diverse membership to provide system-level feedback and guidance about the LWS program, both to SECAS and to the LWS leadership in SEC. This includes examination of science objectives and key required connections. It also includes evaluation of integrated approaches that are necessary for LWS to achieve its broad, long-term goals. Particular attention should be paid to mission architectures and to programmatic requirements.

The LWS MOWG should use the LWS Architecture Committee report as a starting point to articulate an evolving, coherent plan for LWS that is consistent with the current budget realities. The basic science objectives need to be stated in priority order, and a program plan to achieve these objectives needs to be developed. The prioritization of objectives should serve as the basis for the inevitable decisions that will be made in the LWS program. Documenting the goals and priorities of the LWS program and providing a clear exposition of the missions and integrated programs that will achieve these goals should be an ongoing process involving both the MOWG and the LWS program leadership.

Guest Investigator (GI) grants

Guest Investigator (GI) grants play a very important role in NASA's space science program by enabling studies combining data from multiple NASA missions as well as focused studies using individual data sets but undertaken by researchers outside of the original instrument teams. SECAS urges growth of this program element consistent with the constraint that science funding to individual mission teams remains adequate. Some GI funding could be channeled through individual missions if NASA sees advantage in such an implementation , as long as provision is still made for funding studies that cut across several missions, a strength of the existing GI program.

Finally, on a personal note, this was my last meeting as the Chairman of SECAS. Thus, I wanted to take this opportunity to share with the community the tremendous honor that it has been for me

to have served on both SECAS and SScAC with such excellent groups of scientists and to have been able to support, in some small way, the tremendous efforts of the truly outstanding men and women serving the Space Science community at NASA Headquarters.

Sincerely yours,

David J. McComas, Chairman
Sun-Earth Connections Advisory Subcommittee

Dr. R. Fisher, NASA-SEC Director
Dr. M. Mellott, SECAS Executive Secretary
Dr. M. Allen, SScAC Executive Secretary
SECAS members

**Letter from the Chair,
Structure and Evolution of the Universe Subcommittee,
to the Chair, Space Science Advisory Committee**

October 31, 2003

Dr. Andrew Christensen, Chair
Space Science Advisory Committee

Dear Andy,

The Structure and Evolution of the Universe Subcommittee (SEUS) met in public session at the Inn and Conference Center of the University of Maryland on 23-24 October 2003. All current members of the committee were present. As you know, all material presented to the subcommittee may be found on our award-winning website: http://spacescience.nasa.gov/admin/divisions/sz/SEUS0310/.

HST-JWST Transition

The SEU Committee unanimously acknowledges the unique and historic contribution of HST to all of astronomy. This remarkably successful observatory has enriched science and inspired the public for more than a decade. The discoveries it has made have changed the face of astronomy and its influence will be felt long into the future.

We were asked to comment on the HST science transition plan proposed by the Astronomy and Physics Division. Prior to the meeting we had the benefit of reviewing the "Black Panel" report and the HST-JWST Transition Panel report. During the meeting in joint session with the Origins Committee we also heard very thoughtful and comprehensive reports, which we discuss below. We were impressed by the care taken both in the presentation of the proposed Astronomy and Physics Division HST transition plan as well as the presentation of the alternatives considered.

Dr. Kinney presented the proposed Astronomy and Physics Division HST science transition plan, which has two components: complete SM4 and safely de-orbit HST after useful science ceases. The charge to the committee was to comment on this plan.

Following Dr. Kinney's remarks we heard from Dr. Leckrone, who briefed us on SM4 payload status and alerted us to three critical service elements associated with the SM4 mission: gyroscope, battery, and fine guidance sensor degradation. We took special note that HST has a 50% chance of degrading to a two-gyro state by December 2005.

We next heard from Mr. Burch, who briefed us on the costs and risks associated with a potential SM5 servicing mission. He reviewed with us many alternative scenarios for such a mission. We were impressed by the thoroughness of the study.

Dr. Beckwith convinced us that valuable science could be done with a reduced capability HST: a two science gyroscope mode would buy HST an expected 15 months of science lifetime if SM4 servicing is delayed. In light of Dr. Leckrone's presentation this could extend HST's lifetime to March 2007. This is especially important owing to the present uncertainties in the return-to-flight time of the shuttle fleet.

We found Mr. Moore's discussion of propulsion module development studies to be especially helpful. We recognize the need to begin propulsion module development in order to insure that HST can be de-orbited in a controlled manner if, for any reason, HST is not boosted to a higher orbit. We endorse this approach. We note that a shuttle-delivered propulsion module will not be available for a 2005/6 SM4 and would in any case, if included as part of an SM4 mission, displace one or more new science instruments and significantly reduce the science return of SM4. Should SM4 be successful we recommend that the pace and budget profile of the propulsion module development effort be re-evaluated. We note that the need for this capability is agency-wide because there are other orbiting assets that require safe de-orbit and believe that an agency-wide solution should be found.

The committee considered all three of the options described in the HST-JWST Transition Panel report. We note that the Astronomy and Physics Division recommendation is the second of the three options. **The committee reached a consensus that the second option is in fact the correct approach: we endorse completing SM4, operating HST while the observatory is viable and its science capability is compelling and unique, and then de-orbiting the observatory.**

The committee explicitly discussed and rejected the first option of the HST-JWST Transition Panel, which calls for a servicing mission beyond SM4 competed against new space and astrophysics proposals, such as Explorer or Discovery. We were concerned that such a mission would represent a significant departure from the priorities of the astronomical community as described in the recent Decadal report, the Origins roadmap, and the strategic planning process. We feel that any such competition would be intrinsically unbalanced and jeopardize the fast, focused, and agile science investigations that the Explorer and Discovery class represent, and which are so important to the continued vitality and balance of the entire OSS enterprise. **We unanimously endorse the idea that any proposal for a post-SM4 servicing mission should be considered as part of the strategic planning process. We feel that this is proper framework within which the community could consider the merits of a post-SM4 servicing mission in relation to other initiatives.**

HETE-2/SWIFT updates

George Ricker and Don Lamb presented an update on the status of the HETE-2 mission and reviewed recent science highlights. HETE-2 mission operations are currently scheduled to end on January 31, 2004. This was based on the outcome of the 2002 Senior Review. Since this review, several things have happened that support the case for an extension of the HETE-2 operations. First, the launch date for Swift has slipped until mid-May 2004. The 2000 and 2002 Senior Reviews recommended four to six months overlap between HETE-2 and Swift. Without an extension through summer of 2004, this overlap will not occur. Second, the scientific productivity of HETE-2 has increased significantly since the 2002 Senior Review, and HETE-2 has made or directly enabled several important discoveries about GRB's (including the detection of X-ray line emission from alpha-peak elements in GRB020813 and the firm identification of GRB030329 with a Type Ic core-collapse supernova). Finally, the case for a productive synergy between HETE-2 and Swift appears to be even stronger than at the time of the 2002 Senior Review.

On this basis, the HETE-2 team has proposed two actions. First, they request that HETE-2 mission operations be extended through summer 2004. Second, they request that HETE-2 be invited to participate in the 2004 Senior Review to request a further extension of the mission. As part of the NASA response, the Astronomy and Physics Division has undertaken a mail-based peer review of the first request. **The SEUS supports these actions, and recommends that an extension adequate to provide a four to six month overlap of HETE-2 and Swift be funded, provided that the peer review finds that the scientific basis for this overlap is at least as compelling as was judged by the 2000 and 2002 Senior Reviews. If the advice from the peer review is positive, it appears that it would then be reasonable for HETE-2 to participate in the 2004 Senior Review and be allowed to make the case for a further extension of this mission which is now demonstrated to be productive and scientifically useful.**

SEUS also heard a report on the status of Swift, the next scheduled Space Science launch after GP-B(!!!). The expected launch date has now slipped from December 2003 to May 2004 and the Swift mission status is red. Although Swift has apparently resolved issues related to a required harness modification, there is now a possibility of a further schedule slip because of a conflict with Messenger about the use of the Goddard thermal-vacuum chamber. Although Swift had scheduled the use of the chamber previously, Messenger has a constrained launch window. Code S must make a decision about the relative priorities. The result may be an additional slip in the Swift schedule. SEUS is not qualified to make a recommendation about the relative priorities between Swift and Messenger, and can only recognize that an additional slip in the Swift schedule may entail additional unanticipated budget pressures on Code S to get Swift launched and operational. Swift promises to deliver all the exciting and important gamma ray burst science for which it was designed, and we look forward to its eventual launch and successful science operation.

Astronomy and Physics Working Group

In a joint session with the OS, the SEUS heard a preliminary report of the activities of the Astrophysics Working Group from Doug Richstone. The APWG is concerned about the pending decision to divide R&A funding into separate SEU and ASO budget lines. While we recognize that NASA budgets by themes, we recommend that each of the R&A programs support the best science in both the Astronomical Search for Origins and Structure and Evolution of the Universe themes. Thus while SEU may manage the Astrophysics Theory Program and ASO may manage the IR/Radio R&A program, these programs should support the best work in all of Astronomy and Physics without regard to whether it falls into the Origins or SEU themes, or even straddles this boundary.

James Webb Space Telescope

The SEUS was pleased to see the amount of progress reported for JWST. In particular, the re-baseline of the mission to meet the cost goals has resulted in significant decisions being made on the mission design, such as choosing beryllium as the material for the primary mirror and optimizing the number of mirror segments. The choices have made JWST more cost-effective without compromising its primary science goals. We congratulate the team on entering Phase B and are happy to see that the project has maintained its schedule for a launch in 2011. We encourage the JWST team to continue making every effort to hold to this schedule, and encourage NASA to continue funding the mission at a level appropriate to this schedule during Phase B.

Joint Dark Energy Mission

We applaud the efforts to date by NASA and DOE in formulating the principles for cooperation and implementation of the Joint Dark Energy Mission. We look forward to continued multi-agency discussions to tackle the important scientific problem of the nature of the mysterious dark energy, and hope that these multi-agency discussions can be broadened to include collaboration on ground-based and theoretical studies, in order that a more complete and coordinated study of dark energy be accomplished, in line with the recommendations in the NRC Committee on the Physics of the Universe report. **We want to encourage the broadest possible representation on the Science Definition Team, in order to establish Science Requirements that are not linked to any particular implementation strategy.** We encourage regular and timely releases of the data that are used for the key science program, as these early releases serve to improve the quality of data for the Dark Energy problem, as well as other science returns from the mission. (For a supernova-based study, these releases could probably occur yearly without sacrificing the statistical integrity of the primary study samples). We also would like to see the Guest Observer program begin in the first year, limited to data that are not part of the key science program. This will greatly improve the science return of the mission.

Several members of the SEUS were able to participate in a tour of some of the facilities at Goddard Space Flight Center. We would like to acknowledge the efforts of many who made the tour possible.

Respectively submitted on behalf of the SEUS,

Rocky Kolb

Letter from the Chair, Solar System Exploration Subcommittee, to the Chair, Space Science Advisory Committee

TO: **Andrew Christensen, Chair, Space Science Advisory Committee**

FROM: **Jonathan I. Lunine, Chair, Solar System Exploration Subcommittee**

SUBJECT: **Solar System Exploration Subcommittee Meeting**

The Solar System Exploration Subcommittee (SSES) of the Space Science Advisory Committee (SScAC) met October 23-24, 2003 at NASA HQ. The purpose of this memorandum is to summarize the findings of that meeting and ask SScAC to consider them and transmit its recommendations to Mr. Orlando Figueroa, Director of the Solar System Exploration Program and Acting Director of the Mars Program.

Discovery

The defining quanta of the Discovery Program are PI-led missions, competitively selected every 18-24 months to address focused science within a moderate cost cap. For example, for the next AO opportunity development costs are capped at ~$360M in FY04 dollars, including launch vehicle. This mission cap enables the Discovery line to sustain a program with frequent flights at an annual cost of approximately $250M. With 3 missions operating in space, 2 more in development, and 2 currently in formulation, Discovery is appropriately viewed as a highly successful program and has served as a model for the New Frontiers Program (NF), recently initiated with the New Horizons mission to Pluto and the Kuiper Belt (see below). In-depth exploration of the solar system, with its diversity of objects and environments, requires a multi-mission approach of this type.

NASA's third and fourth Discovery missions (Stardust and Genesis) are proceeding as planned - Stardust has successfully executed two samplings of interstellar dust and one sampling of asteroid material. Its final sample (comet dust) will be in January 2004. Genesis has successfully sampled the solar wind for 22 months - critical for understanding isotope ratios in primitive meteorites - and will return to Earth in September 2004. The program has issued its first Discovery data analysis program AO.

The SSES commends Solar System Exploration Division scientists and engineers for their work on a number of current Discovery issues, leading to a situation in which the development of Deep Impact, Messenger, and Dawn appear to have ways to get back on track. The committee is particularly pleased that the Division is aggressively pursuing the implementation of the recommendations made by SSES and SScAC to ensure that Discovery missions continue to be successful and stay within the prescribed cost cap.

HST

As HST reaches the end of its planned operational lifetime, and the JWST is developed to replace it, the Physics and Astronomy Division (PAD) has developed an extended mission plan using one shuttle mission, SM4, to repair systems and install new instruments. A panel of experts convened by Congress supported this plan. A subsequent committee ("The Bahcall Committee") chartered by the PAD recommended adding another repair mission (SM-5) to the Space Shuttle manifest so as to further extend the lifetime of the mission and possibly add more new instruments. In its report, this most recent committee suggested that the SM5 mission be funded in an open competition with the Explorer and/or Discovery lines of low cost missions. SSES is opposed to

the use of the Discovery line as a means of funding the SM5 suggestion, either through an open competition or other means, for reasons given below:

1. The Solar System Decadal Survey states the following: *"Given Discovery's highly successful start, the SSE Survey endorses the continuation of this program, which relies on principal-investigator leadership and competition to obtain the greatest science return within a cost cap. A flight rate of no less than one launch every 18 months is recommended."* Under the prioritized list of flight missions in the decadal strategy, the Discovery flight line is ranked first in the small mission category. The Bahcall committee ruled out enabling the SM-5 mission by altering or canceling missions or programs given high priority in the Academy's Decadal Surveys. In particular, it states: "…no already approved science project would be adversely affected. It is our intention that this process should maintain the relative priorities of the Decade Surveys". This quite appropriate posture appears to be inconsistent with its own specific recommendation to impact the Discovery mission *line*, which is the highest priority effort in the area of small missions in the Solar System Decadal Survey.

2. The cost of the SM-5 mission (estimated by the PAD to range between $0.6-1.2 billion plus launch, depending upon inclusion of new instruments) would require the equivalent of between 3 and 5 Discovery missions as measured in the same way (i.e., excluding launch costs, which normally are included in pricing Discovery missions). Expressed another way, if SM-5 were implemented using the Discovery budget it would put the Discovery program on hold for a period of between 5 and 7 years. It was suggested that some single, comparably scaled competitor could be proposed; however, we found this suggestion unrealistic for several reasons. The selection criteria and ground rules by which the suggested competition would proceed were unclear, and the "related science goals" were not stated. The likelihood of actually providing HST with new instruments *via* SM5 is unknown, so the scope of candidate SSED competitors remains ill-defined. A mission of full-up SM5 scale is not in fact a Discovery mission. A hallmark of Discovery missions is that they are led by scientific PIs, not NASA centers, and provide the opportunity to train future generations of scientists. It was partly on these grounds that the line was approved by Congress, and divergence from this philosophy could lead to the loss of the entire program. Even were it not to do so, a 5- to 7-year program suspension would put any future Discovery missions beyond the horizon of the Solar System decadal plan. It could also lead to an even longer flight hiatus, as PI expertise and hardware lines for Discovery might be lost and would have to be ramped up again at the end of this period. Finally, changing from a multi-mission to a single-mission philosophy harms SSED's ability to explore diverse solar system targets.

Overall, in our judgement, the cost to SSED mission diversity and science return would far outweigh any possible benefit from a currently ill-defined SM5 mission to extend HST, if that were accomplished using Discovery resources (deemed high priority by the Decadal Survey) as proposed by the PAD's *ad hoc* committee. We support the PAD plan to extend and reequip HST with their own resources, using an SM4 mission.

New Frontiers Program

The New Frontiers (NF) Program fills the need for a larger, intermediate class of PI-led missions, prioritized and recommended by the Solar System Decadal Survey of the NAS. NF is off to an exciting start, with the recent issuance of an AO for the four Decadal Study (DS) mission concepts remaining after New Horizons. The NF AO also provides for the ongoing review and selection of at least some extended missions - a need long recognized by NASA and the SSES. NASA has begun to plan how to regroup around DS science concepts which remain unselected, for whatever reasons, at the outcome of the AO selection process. For instance, it is foreseeable

that either (a) while all relevant technology is mature, one or more of the DS mission designs will be found to be unachievable within the NF cost cap, or (b) one or more of the DS mission designs will be absent from the responses because of real or perceived immaturity of enabling technology.

A feasible response to (a) would be, as proposed by NASA, to constitute Science Definition Teams (SDTs) with the charge to refocus missions which are too expensive on some highest priority subset of the DS science goals. We are concerned that existing, unconnected technology development programs may not, in fact, be adequate for responding to (b). Some aspects of Code R's "Technology for Extreme Environments" program might be applicable starting in FY05, but there is no method for determining if these are the most important technologies for NF, for providing guidance on their progress, or for complementing them with new efforts as needed by NF. A solution would be to establish technology development teams (TDTs) within NF with the specific goal of bringing enabling technology for the unselected DS mission profiles to maturity.

Overall, we suggest that NASA develop a plan to constitute Science Definition teams and Technology Definition Teams (SDTs and TDTs), working within the NF program, to refocus science goals and advance immature technologies for unselected DS missions. Having such a plan in advance may even allow for a more satisfying conclusion to the AO process.

Mars

MSL: SSES shares concerns expressed by the Mars Exploration Program Analysis Group (MEPAG) regarding growing threats to the ability of the Mars Scientific Laboratory (MSL) to accomplish its scientific objectives within budget. Not only does MSL face the typical cost growth that occurs during pre-phase-A as the mission technical design matures, but its proposed use of nuclear power raises the possibility that it must comply with category IVc planetary protection criteria, which will require significant additional funding.

It is encouraging that the instruments needed to make critical measurements for MSL appear to be in development in the various technology programs (e.g., MDIP and ASTID). However, the integration of even mature instruments and sample handling devices into the needed package is not trivial and will require significant funding. There are concerns, for instance, that even a fully and thoroughly sterilized spacecraft could contain enough bioload to compromise investigations that "follow the carbon" in the Mars environment. The SSES recommends that MEPAG proceed with its plans to address this issue in more depth, in collaboration with the MSL project.

As MSL tries to balance expectations and resources, it is important that the mission continue to meet or exceed the minimum science floor defined by the Project Science Integration Group (PSIG) in terms of mobility, lifetime, and payload, including the acquisition and proper analysis of samples. While it may be tempting to return to a solar powered mission to constrain costs, including those associated with planetary protection, the SSES worries that the resulting mission would be compromised in its ability to carry out the required program of scientific measurements at higher latitudes, the region of greatest scientific interest for astrobiology.

Post-MSL: The Next Decade plan, prepared by the Mars Science Program Synthesis Group (MSPSG), which was chartered by NASA and included MEPAG members, program engineers, and advance planning engineers, is an excellent response to the OMB challenge to define a post-MSL Mars program. The plan proposes four "pathways" for Mars exploration in which a particular sequence of missions would respond, within a Mars Exploration Program funded at the current level (plus inflation), to specific major discoveries by near-term missions. The SSES endorses the view that the order and timing of major missions for the next decade (post-MSL) should build on the discoveries of the current program of Mars exploration.

However, the SSES also resonates with the concern expressed by MEPAG that the Mars exploration program may become too limited in scientific scope. In the current pathways plan, the broader understanding of Mars geology, atmosphere, and geophysics is a primary objective of the major missions only if all avenues for exploring habitable environments are exhausted. Network and future orbiter missions (e.g., aeronomy) are identified only in that pathway and only then after sample return. Thus, the SSES believes that the AO's for Scouts should not dictate specific science roles in particular pathways, but rather continue to allow proposers the freedom to develop missions with a broad scientific and technical scope.
The present Next Decade plan also assumes that the "best" sites for exploration after MSL can be derived without further orbital reconnaissance and "ground truth". While many good sites will surely be identified, the SSES worries that there remains a significant risk that a sample return or astrobiological robotic laboratory might be directed to a nonproductive site. None of the pathways has a mission examining many sites, although the challenge would be to do so with appropriately powerful in situ instruments. SSES intends to explore this complex issue in more detail in future meetings.

PDS
Progress on the Planetary Data System (PDS) appears to be satisfactory, and will be of significant value to the planetary community in managing the increasing large data sets produced by current and planned missions. Our discussions on this topic suggest that current NASA plans may not be sufficiently aggressive in developing an integrated data system and associated tools that would permit a larger group of scientists, including those without direct mission experience, to utilize these data sets. Scientists in other disciplines, ranging from paleobiology to molecular biology, have discovered that the effort required to develop this technology is well worthwhile. By increasing the ease of access to such data, scientists spend less time managing data and more time answering questions to which the data can be applied. Further, the availability of data in such formats will encourage new scientists to enter the field; this generally has substantial positive impacts. Experience with some large data systems (e.g., the early EOSDIS) indicates that care must be taken to ensure that this development does not get out of hand. PDS should first give emphasis to basic capabilities. Capabilities beyond this need not--perhaps should not--be developed by PDS itself, but instead could be developed as the result of a peer-reviewed competition.

Instrument Development (other than Mars)
The committee is concerned that Code S, leaving aside the Mars and astrobiology programs, does not have an ongoing program to support instrument development through the mid-TRL levels (i.e., beyond breadboards up to flight demonstration). The PIDDP program as currently constituted is charged with supporting instrument definition and development only through breadboard level. The lack of a mid-TRL instrument program means that certain measurement concepts are rejected out of hand during mission definition, or that added risks are assumed when a mission with new instruments is selected for development. Instrument development risks are often important or dominant contributors to overall mission risk. The cost-capped mission program lines, in particular, would benefit from a mid-TRL instrument development program, and the Committee would strongly support mission risk reduction via such a program.

Astrobiology
SSES congratulates Dr. Bruce Runnegar of UCLA on his selection as the new Director of the NASA Astrobiology Institute and wishes him well as he takes the helm from Acting Director Dr. Rosalyn Grymes, who has ably led the institute since the departure of Dr. Barry Blumberg. With the recent recompetition the NAI has moved into a phase of maturity in which new institutions

and new programs are being included. The institution of the focus groups and extensive field programs are the most recent notable and positive accomplishments of the NAI. The SSES notes that, given the increasing number of field expeditions involving sample collection under the partial aegis of the NAI, a plan needs to be developed for the curation, distribution and dissemination-of-information-on the field samples. The cycle of intense competition among teams, followed by a 4-year cooperation including sharing of data and personnel, followed by another intense completion, constitutes a sociological experiment not explicitly considered in the management of the institute and –for example—the implementation of the virtual institute technology. It is essential that the NAI director, and NASA itself, follow the impact of these features of the NAI on scientific productivity and education of students in astrobiology. With regard to the long-term future of astrobiology, SSES raises two issues: (1) Is the balance between the small core of co-investigators, whose research is at least partially funded through NAI, and the halo of collaborators, with minimal or no NAI funding, appropriate for the growth of this nascent field toward critical mass? (2) Is there a proper balance in funding among NAI, R&A, NSCORTs and technology development programs? SSES intends to examine these issues in more detail in the future.

Finally, let me close by expressing the committee's best wishes to Colleen Hartman as she departs NASA and pursues new challenges elsewhere in the Federal Government. Her superb abilities as Solar System Exploration Division director will be missed, but the committee is very pleased that Mr. Orlando Figueroa has been appointed to this position. His able leadership in the Mars Exploration Program during a crucial period in which the MER's were prepared and launched has been key to that program's forward momentum. We wish him well in his new position, and urge the Office of Space Science to move ahead as soon as possible to permanently fill the Mars Exploration director's position.

With best regards,

Jonathan I. Lunine
Chair, Solar System Exploration Subcommittee

[1]Space Studies Board, Assessment of Mars Science and Mission Priorities, National Academies Press, 2003.

Letter from the HST–JWST Transition Panel to the Chair, Space Science Advisory Committee

Dr. Andrew Christensen 16 November 2003
Chair, Space Science Advisory Committee

Dear Dr. Christensen:

We understand that you will receive reviews on the recommendations of the HST-JWST Transition Panel from the advisory sub-committees to the Physics and Advisory Division of the Office of Space Science.

The Chairs of the sub-committees have graciously provided us with preliminary copies of these reports so that we could study them before the SScAC meeting on November 17th.

The draft reports that we have seen are based upon a misinterpretation of our panel report, namely, that our recommendation to compete an SM5 by peer review against future scientific programs that might be considered by the OSS would undermine Decadal Survey priorities or previously established NASA programs. Indeed, this is a remarkable misinterpretation of our recommendation since every living chair or co-chair of an Astronomy and Astrophysics Decadal Survey was either a panel member (John Bahcall and Christopher McKee) or a reviewer of our report (George Field and Joseph Taylor).

Our report specifically described the boundary conditions for the proposed competition as "No already approved science project would be adversely affected. It is our intention that this process should maintain the relative priorities of the Decade Surveys."

We think that there are two reasons for this misinterpretation. First, our report stated:...should then be peer evaluated in competition with other comparably sized new scientific proposals [such as those within the Explorer or Discovery programs]". Our recommendation was complete without the words in [square brackets]. Throughout the other parts of our report, we scrupulously avoided specifying how our suggestions were best implemented administratively. In retrospect, we regret having added the illustrative phrase "such as" in this recommendation. Second, no representative of our panel was put on the agenda of any of the sub-committee presentations. Thus we could not participate in the discussions where the misinterpretation arose and clarify our intention in real time.

To be explicit, we suggested that NASA should compete by peer review SM5 against future comparably sized astrophysics programs, programs not already approved in the NASA program or recommended by Decadal Surveys. We intended that SM5 science proposals should be competed against proposals with similar science goals and that the peer review choices should be made by scientists within the appropriate discipline after explicit scientific proposals are reviewed.

Subsequent to our report, it has been determined that the costs associated with the science component of an SM5 mission are in the range 0.5-1.2 billion dollars, provided that HST is deorbited with an ELV. If the Physics and Astronomy Division does not plan to consider any future science programs with total funding in this range, then no competition will be possible. But, we hope and believe that the Physics and Astronomy Division will at least consider future programs in this range. Furthermore, we recommend that consideration be given to the option of

using SM5 to attach a propulsion module to HST, since this option for deorbiting HST could in principle be superior to an ELV and it has the potential of reducing the total cost of an extended HST mission.

We recognized that the creation of a plan for an appropriate competition is a difficult task. But; we expected the OSS to develop a plan whereby the competition could be carried out on a level playing field. We think this has not happened, but we think the challenge of creating an appropriate competition could be achieved with appropriate community and NASA involvement.

We thank you very much for permitting our panel's views to be heard directly, and we hope that you and your committee will be able to develop a mechanism whereby SM5 can be considered in the context of an appropriate competition.

Sincerely yours, John N. Bahcall, Barry Barish, Jacgeline Hewitt, Christopher F. McKee, Martin Rees, and Charles Townes.

Letter from the Chair, Space Science Advisory Committee, to the Associate Administrator, Space Science

SPACE SCIENCE ADVISORY COMMITTEE

1 Dec. 2003

Dr. Edward Weiler
Associate Administrator for Space Science
NASA Headquarters
Washington, DC 20546

Dear Dr. Weiler,

The Space Science Advisory Committee (SScAC) met in public session November 17-18, 2003 at the NASA Ames Research Center. We were warmly welcomed at the beginning of our meeting by the Center Director Scott Hubbard. He set the tone of hospitality we felt throughout the meeting, from the smooth operation of the meeting logistics, facilities and meals to the informative tour of laboratory facilities.

We welcomed two new members of SScAC: Jonathan Grindlay, representing the astrophysics community, and Michelle Thomsen, the new chair of the Sun Earth Connection Subcommittee (SECAS). With their arrival we bade farewell to Charles Beichman and Dave McComas, who served three-year terms, and thanked them for their work on the committee. All members were in attendance throughout the meeting. We would also like to thank Marc Allen, Marian Norris, and their staff for their leadership and efforts in support of a successful meeting.

The first day of the meeting was dominated by consideration of the Bahcall Panel report regarding the future of the Hubble Space Telescope (HST) servicing missions. We had expected this issue to be somewhat controversial and had accordingly budgeted time in the schedule for public comment. As it turned out, the content of the discussion was distilled fairly quickly to the consensus items outlined in this letter and no public comment was offered. However, the committee received two letters regarding HST from interested external groups (included as attachments). We heard from Chris McKee, a member of the Bahcall committee; Anne Kinney, the Origins theme director; and the sub-committee chairs, who summarized the discussions from their respective sub-committee meetings. Steve Beckwith, the director of the Space Telescope Institute presented a briefing describing the science that could be carried out if HST were to operate with only two gyros.

We received our annual ethics briefing by Kevin Kouba and heard reports from Anne Kinney, Richard Fisher, and Orlando Figueroa regarding issues in their respective themes. Dave Bohlin described a proposal to rationalize honoraria for review teams.

We continued with our tradition of excellent noon-time talks from leading space scientists. On Monday Robert Lin reviewed the outstanding results of the RHESSI mission's pioneering observations of solar high-energy radiations. On Tuesday Dave Des Marais and Chris McKay introduced us to the astrobiological science activities at Ames. These timely presentations were of great interest following the enlightening tour of some of the Ames laboratories that the committee enjoyed on the previous evening.

Ron Greeley and Torrence Johnson, chair and co-chair of the JIMO Science Definition Team (SDT), gave us a summary of the SDT deliberations and conclusions regarding the science requirements for the JIMO mission.

RECOMMENDATIONS

The Future of HST

At our previous meeting of SScAC the Bahcall Committee Report had just been released and we were awaiting the release of the Columbia Accident Investigation Board (CAIB) report to better understand the issues with using the Shuttle to service the Hubble Space Telescope (HST). We appreciate now that the CAIB report has significantly changed the environment in which the Shuttle must operate. It is no longer to be thought of as an operational system. The report states "…operation of the Space Shuttle, and all human space flight, is a developmental activity with high inherent risks." It was with this new perspective that SScAC considered the recommendations of the Bahcall panel convened to consider the transition from HST to James Webb Space Telescope (JWST) science operations.

The Bahcall panel considered three options for future Shuttle servicing missions (SMs) to service and upgrade the instrumentation on HST. In their report these options were prioritized as follows:

1. Two additional Shuttle servicing missions, SM4 in about 2005 and SM5 in about 2010, in order to maximize the scientific productivity of the Hubble Space Telescope. The extended HST science program resulting from SM5 would only occur if the HST science was successful in a peer-reviewed competition with other new space astrophysics proposals.

2. One Shuttle servicing mission, SM4, before the end of 2006, which would include replacement of HST gyros and installing improved instruments. In this scenario, the HST could be de-orbited, after science operations are no longer possible, by a propulsion device installed on the HST during SM4 or by an autonomous robotic system.

3. If no Shuttle servicing missions are available, a robotic mission to install a propulsion module to bring the HST down in a controlled descent when science is no longer possible.

The report stressed that peer-review competition was a guiding principle in the selection of science missions within OSS. SM-5 should be peer-reviewed and funded through existing funding lines, such as the Explorer/Discovery lines, wherein the science component of SM-5 mission could be competed against proposals with similar science goals and cost. [As noted in a letter to SScAC dated 16 Nov. 2003, after their report was issued the Bahcall panel was informed that the costs associated with the science component of SM-5 would be substantially greater than the estimates available to the committee during its deliberations.] Therefore some other plan for an appropriate competition with "comparably sized astrophysics programs" should be worked out that will not undermine priorities in the NRC Decadal Surveys, which have consistently recommended a robust (and accelerated) program of peer-reviewed, PI-led Explorer and Discovery class missions. Moreover the key assumption regarding the launch date of SM-4 appears to have been invalid. NASA now expects an SM-4 flight no earlier than mid 2006 or early 2007.

The SScAC received reports from its four subcommittees regarding the Bahcall report and heard presentations by NASA management and Chris McKee, one of the authors of the report. Aware of the new realities regarding Shuttle usage and availability, the SScAC found strong consensus on the following items.

1. The SScAC affirms the enormous scientific contributions that have been made by HST, and has no doubt that an extended HST mission enabled by the SM-4 servicing mission would continue that heritage.

2. The overriding criterion for the selection of missions in OSS is compelling science content. Furthermore, any future peer-reviewed competition for HST-related missions should be judged against missions of comparable size. In view of the estimated cost of SM-5, the subcommittees felt that the use of the Explorer/Discovery mission lines was inappropriate. **SScAC does not endorse any plan that adversely affects the Explorer or Discovery mission lines.**

3. The SScAC strongly supports SM-4 because it will clearly achieve first-rate science, in the long-standing tradition of HST. The increased wavelength coverage and sensitivity of Wide Field Camera 3 (WFC3) as planned would represent a more than ten-fold improvement over existing ultraviolet and infrared capabilities, while the planned improvements in the Cosmic Origins Spectrograph (COS) should enable HST to make forefront contributions in the years ahead to our understanding of both the "local" neighborhood and "distant" universe. In addition, new gyros and batteries should enable HST to operate to the end of the decade provided a servicing mission can be accomplished without additional delays

   We also recognize there are significant threats to completing SM-4, including access to the Shuttle and the ever-increasing costs of delaying the mission past FY04. Moreover, extension of the useful life of HST requires a servicing mission before hardware failures occur that prevent it. **The SScAC reaffirms the high scientific priority of SM-4, and recommends that SM-4 be carried out at the earliest possible date. NASA should execute existing plans and schedule this mission for as soon as possible after the safe return of the space shuttle to flight status.**

   SScAC further recommends that, after SM-4, NASA should continue to operate HST as long as the science capability is compelling and unique, or until the need to de-orbit HST safely requires a graceful end to this extremely successful space science mission.

4. The first option proposed by the Bahcall committee calls for NASA to carry out two servicing missions, SM-4 and SM-5. This option also raised several issues and concerns including the future availability of Shuttle, the availability of future OSS funding, and the science value of HST compared to other new, yet to be approved, science initiatives. SM-4 is called out in the OSS strategic plan and initial funding has been identified. **SScAC recommends that any servicing of HST beyond SM-4 should be considered during the strategic planning process, wherein the science value of SM-5 would be compared to other future science initiatives in the Origins program.** This approach is consistent with two principles that have enabled OSS science programs to succeed over the last decade: 1) the principle of strategic planning based on the most compelling science objectives identified in a broad, community-wide discussion; and 2) the principle of a discipline-balanced program, with cooperation and mutual support across the

Enterprise enabling striking successes on a broad front. Significantly deviating from these principles could seriously cripple the effectiveness of the OSS in the future.

Discovery

The SScAC endorses Orlando Figueroa's plan for process improvements in the Discovery and New Frontiers mission lines. We were very pleased to see that this plan implements the recommendations made by the SScAC at our last meeting. A key element is the restructuring of the Discovery and New Frontiers Program offices to reflect the Explorer Program model for program management, systems engineering and flight assurance support.

Science Centers

The SScAC appreciated the information provided by Anne Kinney regarding Science Centers and their selection. **SScAC remanded this issue back to the Origins Sub-committee for further study.**

JIMO

The Jupiter Icy Moons Orbiter (JIMO) Science Definition Team (SDT) presented a summary of the process used to arrive at their recommended science objectives for this mission. **We commend the SDT for their thorough and inclusive work, and for their efforts in prioritizing measurement objectives from the diverse input received.** The proposed science is exciting and well aligned with the NRC Solar System Exploration Decadal Survey goals and NASA strategic planning.

The measurement requirements for JIMO present challenges in the development of instruments that take advantage of the capabilities offered by Project Prometheus. **We recommend that Project Prometheus follow the lead of the JIMO SDT by maintaining close ties with the science community during the phasing of JIMO instrument and Project Prometheus spacecraft development and integration activities.** We are encouraged by the apparent good relations between the solar system exploration program and Project Prometheus, and the promise of closer relations in the future between the broader OSS community and the Project by including scientists from other Space Science themes.

ST-5

The SECAS brought before the committee an issue regarding ST-5, a New Millennium mission of high priority to the Sun-Earth Connections research (SEC) community. The mission will provide flight validation of mission-critical elements needed for Magnetospheric Constellation and other multi-spacecraft SEC missions in the Solar Terrestrial Probes queue. Prompt flight validation is required to reduce the risk for these other missions. Despite diligent efforts by the program to find a launch ride of opportunity as a secondary payload, none has been found, placing the ST-5 flight at serious risk. The program has no budget to purchase access to space. **SScAC supports SECAS' recommendation that a dedicated Pegasus launch vehicle be purchased and that the launch of ST-5 proceed as soon as possible. The consequential delays of ST-10 and ST-11 that would result from the increased cost of this option are deemed an equitable and reasonable programmatic tradeoff.**

Honoraria

The SScAC considered a proposal to standardize policy concerning honoraria for panel reviewers. We heard that there are approximately 100 NRA panels constituted each year to evaluate research proposals submitted to the SR&T and other programs. In view of the additional cost and the unclear benefit to be derived, **SScAC recommends that current policy regarding honoraria not be changed.**

Sounding Rocket Operations

The committee's briefing on the status and plans in the sounding rocket (SR) program could not be sufficiently discussed due to time constraints. There are evidently serious funding issues throughout the program: for example, insufficient funds were available to carry out the currently planned flights at White Sands and the campaign in Kwajalein. A new capability was demonstrated for "tailored" trajectory experiments, but the required rocket motors are not currently available. A development plan for new technology was presented, but the lack of dedicated funding caused the committee to wonder whether this plan is likely to meet its goals. **Given the value of this program as outlined in the OSS strategic plan, SScAC looks forward to an opportunity to fully air the issues raised by this briefing at a future SScAC meeting.**

Sincerely

Andrew B. Christensen
SScAC Chair

Attachments:
SECAS Report [see Appendix F]
SSES Report [see Appendix H]
OS Report [see Appendix E]
SEUS Report [see Appendix G]
Letter from the Space Telescope Users Committee
Letter in support of the Explorer Program
Letter from the Bahcall committee [see Appendix I]